Determination Of Indicators Of Ecological Change: Ft. Benning, GA

Project Number CS-1114A-99

University of Florida
Purdue University

K. Ramesh Reddy

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Research Team

- **Bill DeBusk,** University of Florida, Soil biogeochemistry
- **Wendy Graham,** University of Florida, Subsurface hydrology, spatio-temporal modeling
- **Jennifer Jacobs,** University of Florida, Surface hydrology
- **James Jawitz,** University of Florida, Subsurface hydrology
- **Debbie Miller,** University of Florida, Vegetation ecology, habitat integrity, biodiversity
- **Andy Ogram,** University of Florida, Soil microbiology
- **Joe Prenger,** University of Florida, Soil Microbiology
- **Suresh Rao,** Purdue University, Subsurface hydrology, modeling
- **Ramesh Reddy,** University of Florida, Soil biogeochemistry
- **George Tanner,** University of Florida, Vegetation ecology, habitat integrity
- **Several graduate students and post docs.**

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Outline

- Introduction
- Background
- General Conclusions
- Research Report FY2001-02
- Research in Progress FY2002-03
- Products

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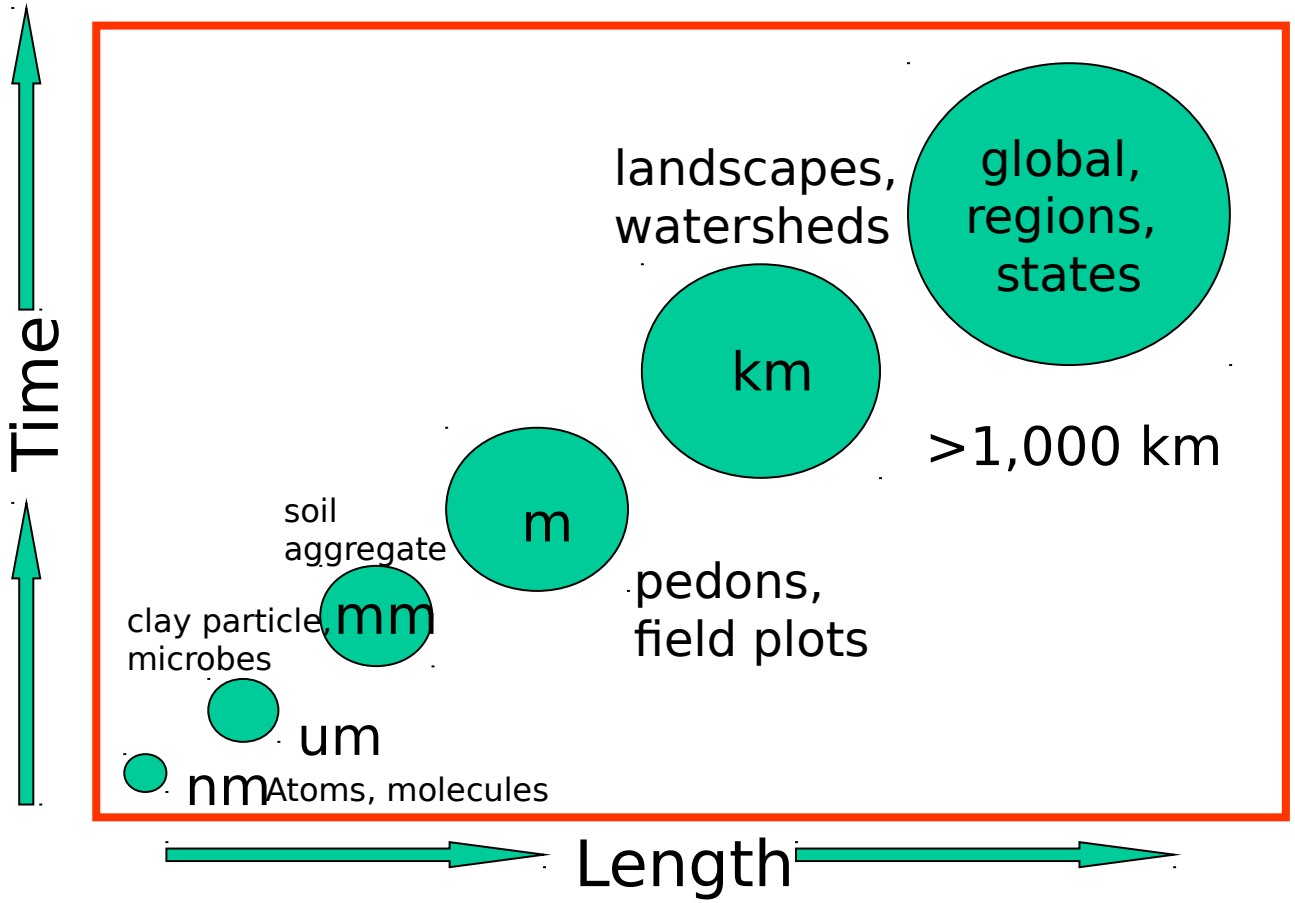
Technical Objectives

- **Identify physical, chemical and biological variables (properties and processes) associated with soil, surface/subsurface hydrology and vegetation that may be used as indicators of ecological change**
- **Evaluate potential ecological indicators based on sensitivity, selectivity, ease of measurement and cost effectiveness**

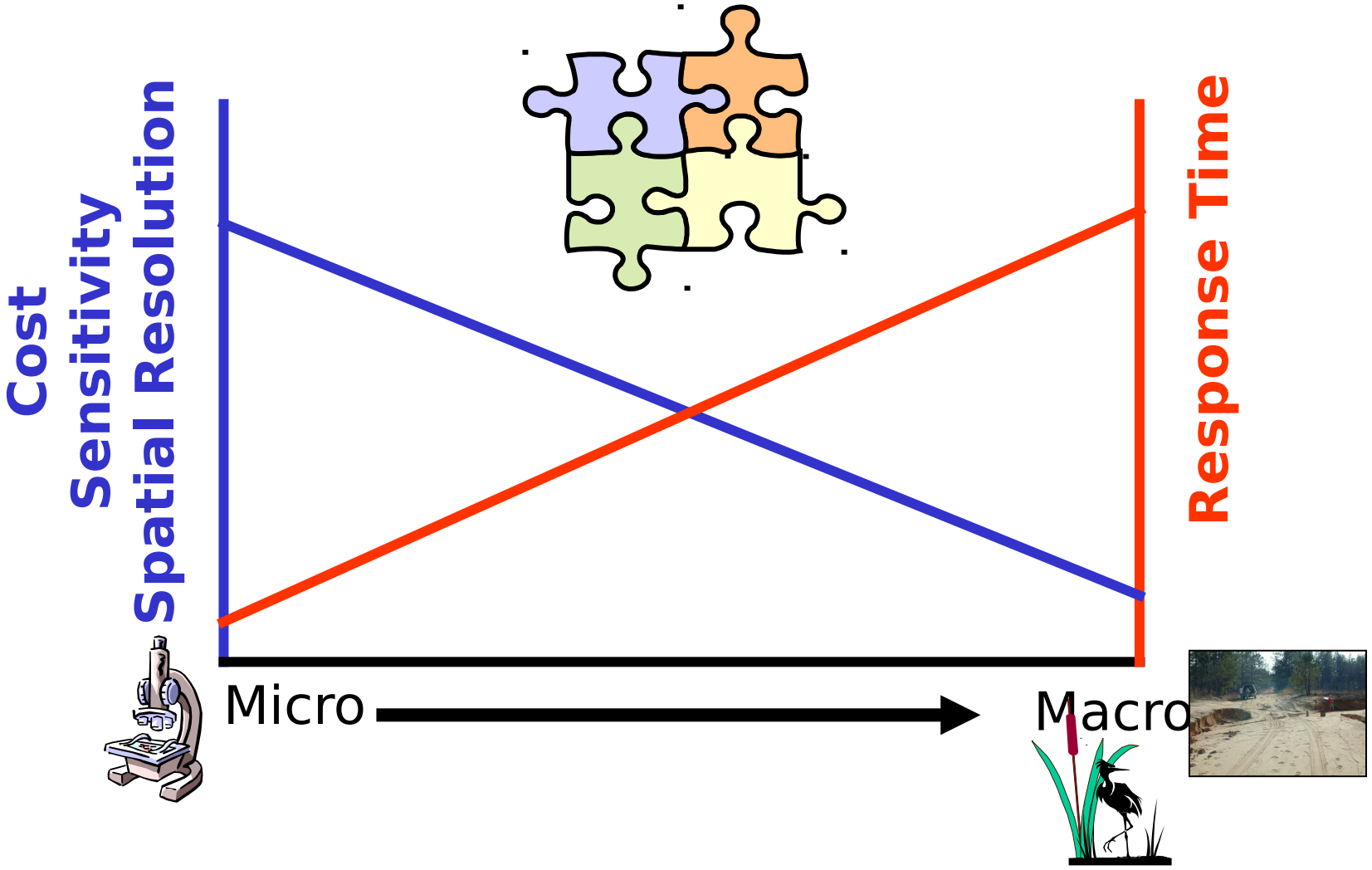
Technical Objectives

- **Select Indicators that most effectively:**
  - **Show a high correlation with a certain state in a specific ecosystem**
  - **Provide early warning of impending change**
  - **Differentiate between natural ecological variation and anthropogenic impacts**
- **Determine the likely range of natural variation for indicator variables, and compare with the range of values under anthropogenic, especially mission-related influences**

Spatial and Temporal Scales



Ecological Indicators



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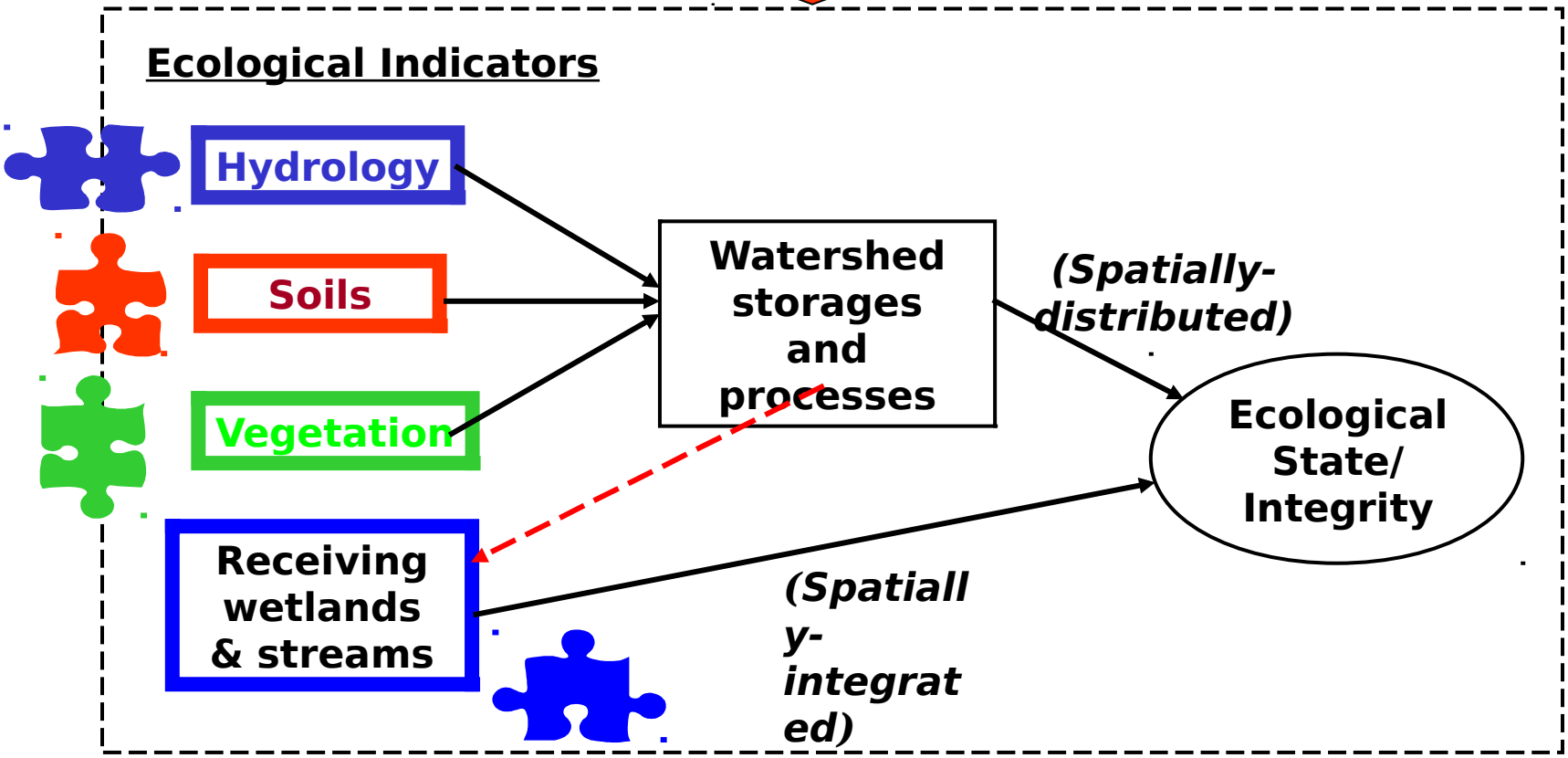
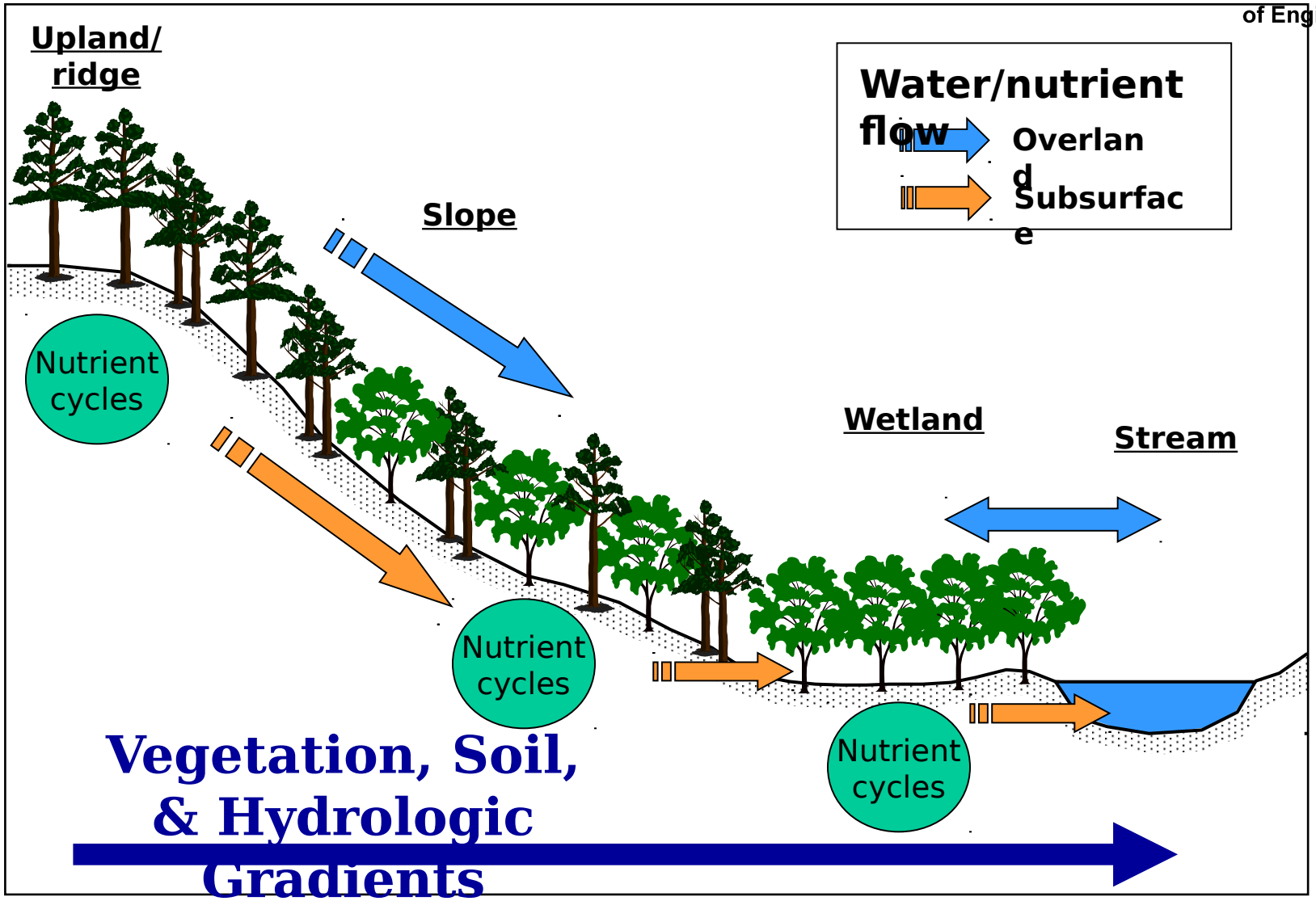
Spatio-temporal change

- Intrinsic/natural factors
- Extrinsic/anthropogenic factors




Upland/
ridge
Slope
Water/nutrient
flow
Overlan
d
Subsurfac
e
Nutrient
cycles
Wetland
Stream
Nutrient
cycles
Nutrient
cycles
Vegetation, Soil,
& Hydrologic
Gradients

Assessment of military and non-military impacts

Tree harvest and vegetation clearing

Military training

Roads

Fire

Sampling Approach

- **Phase I – Regional Scale Sampling**
  - 6 watersheds of order 4-5 (coinciding with ECMI monitoring units)
  - Characterize indicator variables
- **Phase II – Local (Sub-Basin) Scale Sampling**
  - 2nd and 3rd order watersheds within Phase I units
  - Evaluate local-scale variability and temporal trends
- **Phase III – Re-Sampling**
  - Validation of selected indicators
  - Evaluate temporal changes

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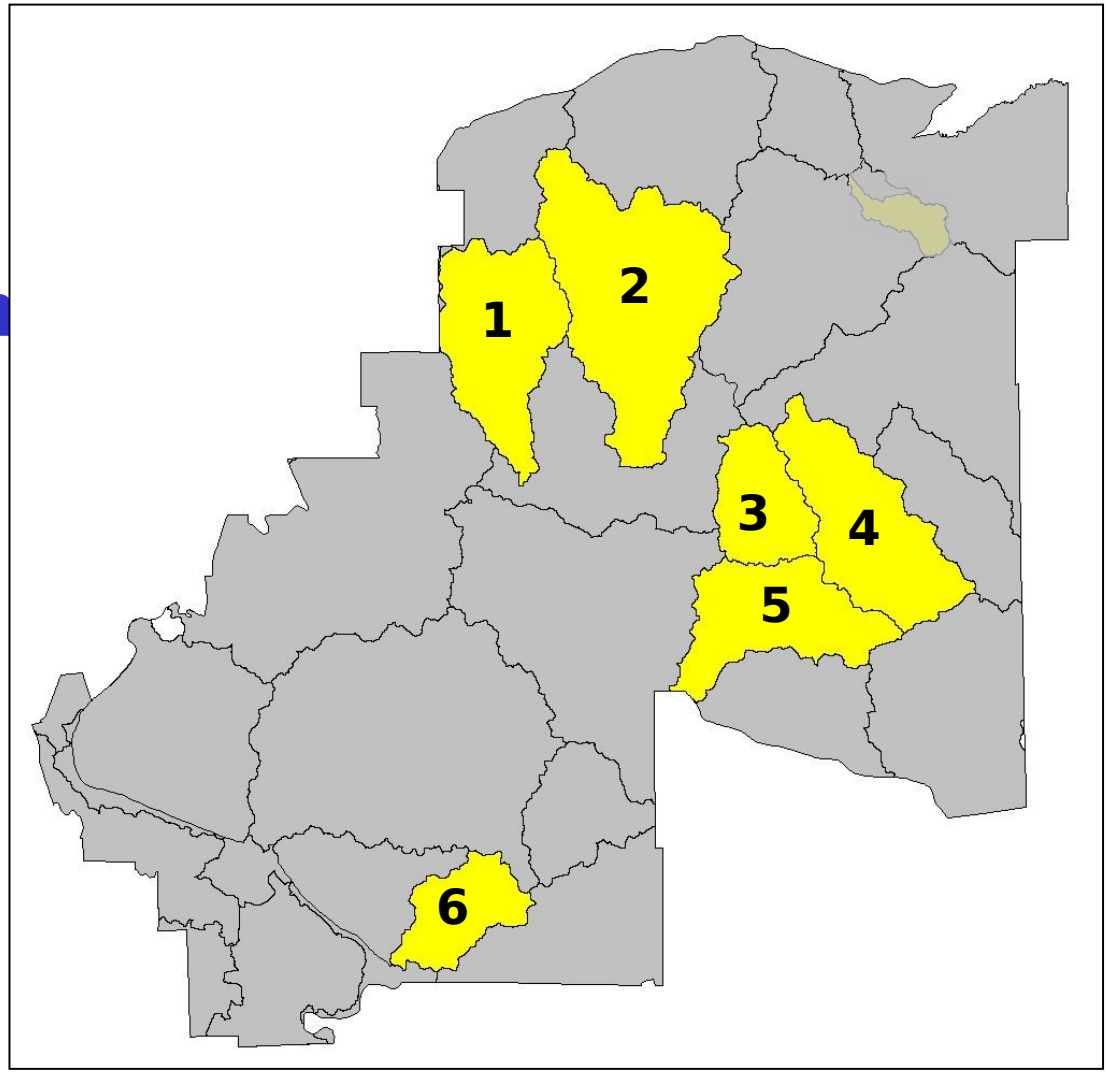
PHASE I
Sampling Domain

1. Wolf Creek
2. Randall Creek
3. Bonham Creek
4. Sally Branch
5. Halloca Creek
6. Shell Creek



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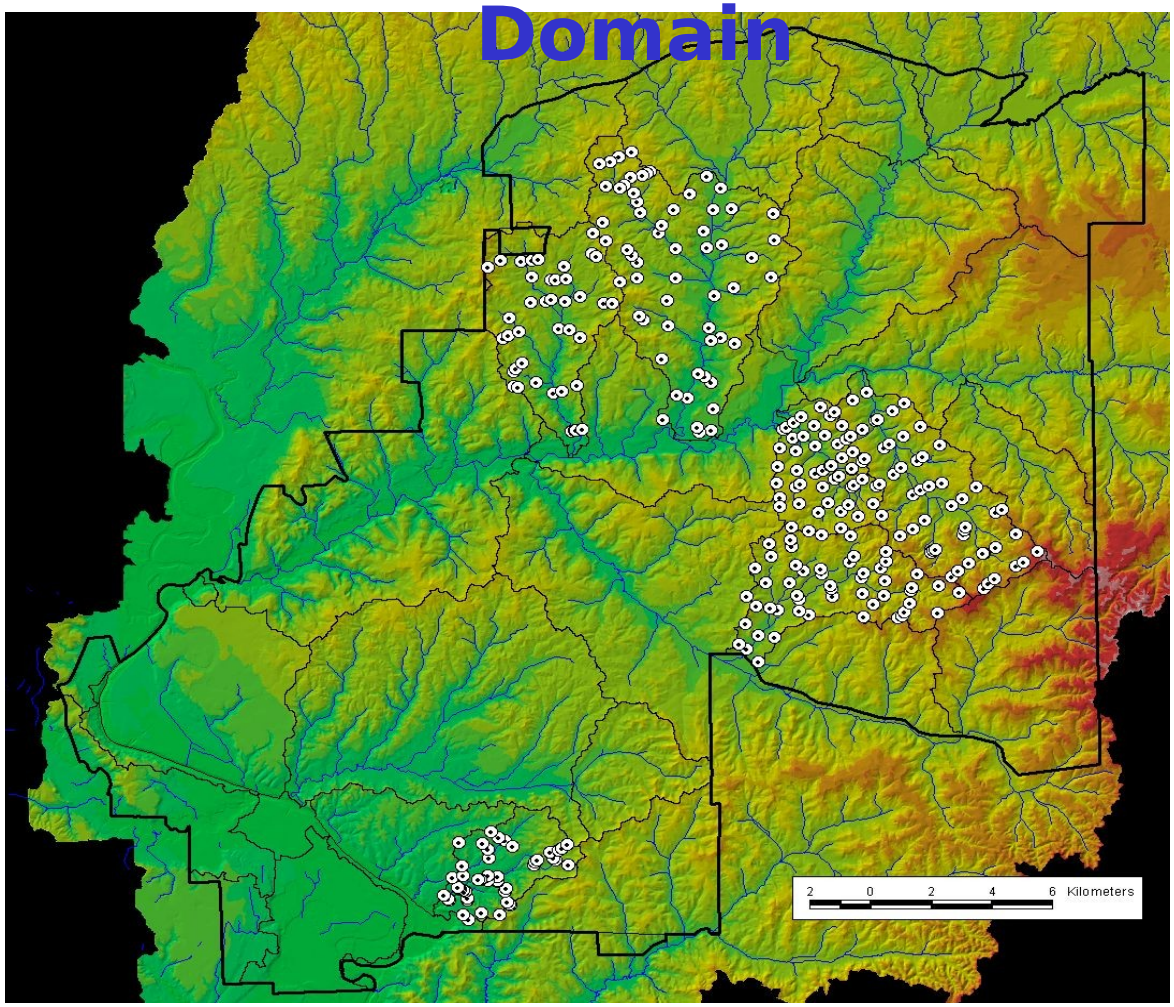
PHASE I - Sampling Domain



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UF/IFAS CNR
Ecosystem Research Outreach Education Sustainable Solutions

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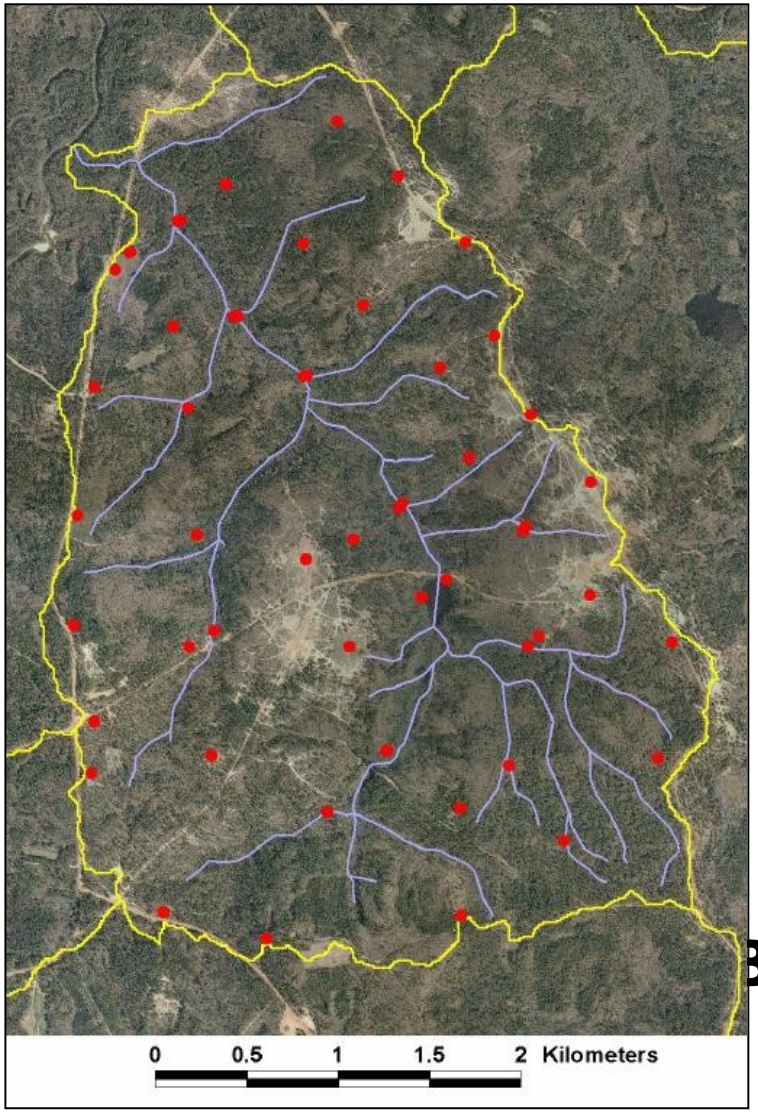

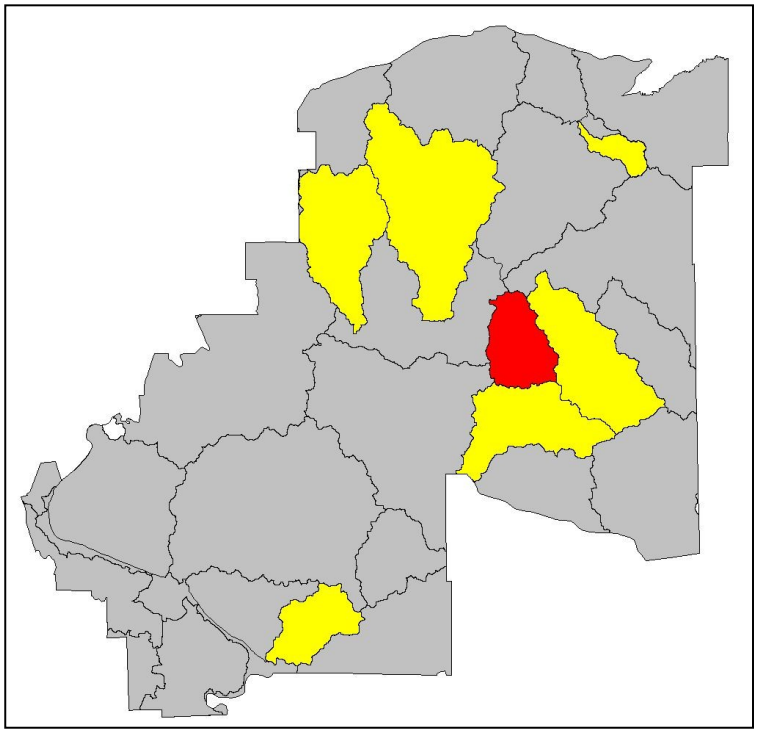

Phase I
Soil Sampling
Bonham Creek Watershed
ECMI Monitoring Unit 11

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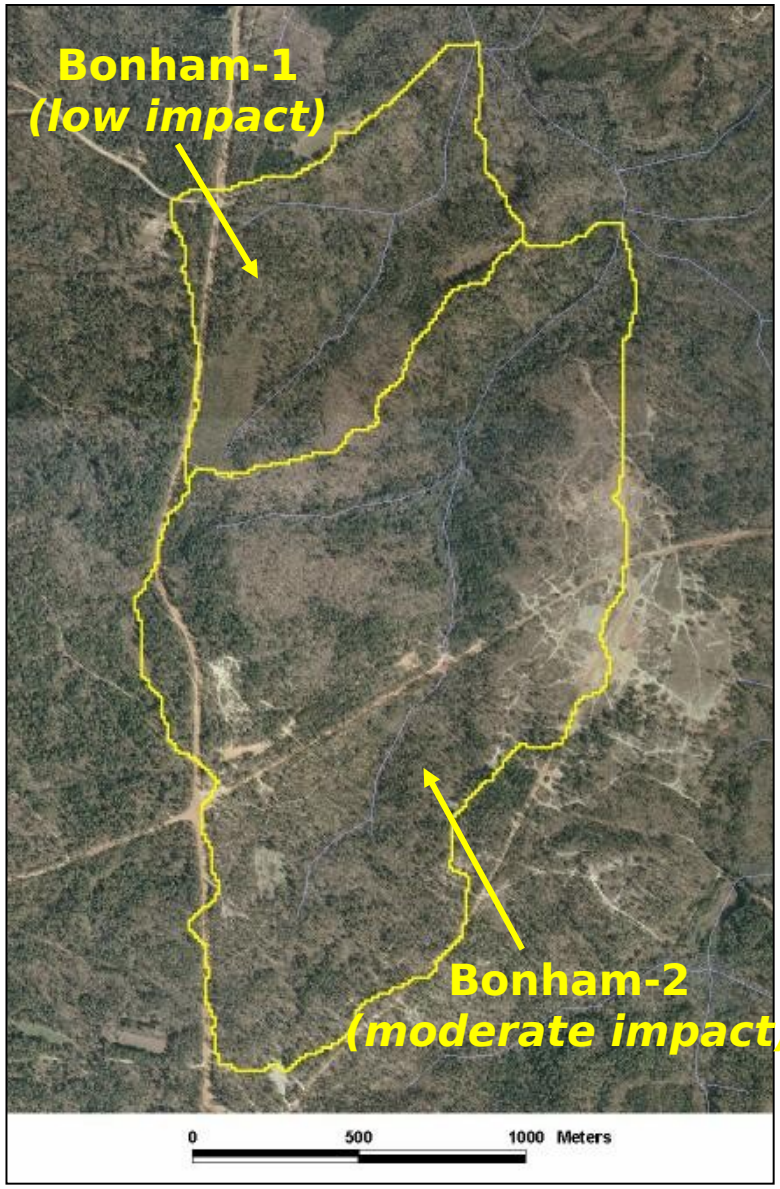

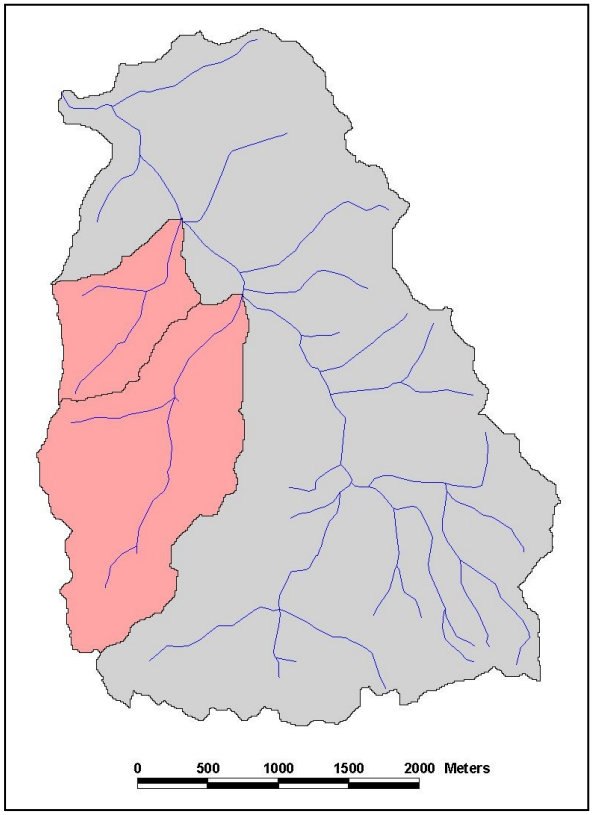

2nd Order Watersheds Bonham Creek

General Conclusions

- Approximately 2-15% of the throughfall shows up as stream flow. Median value ~6%. Time to peak discharge is approximately 3 hours.
- Storm intensities are usually $<K_{sat}$ at most places, except severely disturbed areas.
- Soil cover plays an important role in determining the potential runoff. More important that K_{sat} of surface soil.
- Biogeochemical cycling in soils and vegetation are influenced by soil-water

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General Conclusions

- **Soil organic matter and its cycling is an important biogeochemical indicator.**
- **Spectral analysis shows excellent promise to determine soil nutrient status.**
- **Understory vegetation species diversity.. Clear indicators generally observed only at heavily impacted sites.**
- **Nutrient and sediment loads in “low” and “medium” impact sites are not too large. Sediment may be the most important water quality attribute for “severe” impact sites.**

General Conclusions

- Water quality measurements revealed low levels of most nutrients.
- Decreased canopy cover in wetlands and hardwood communities increased the nutrient load to streams.
- Riparian zones may be the most important determinants of water quality.
- Multivariate Analysis, Principal Component Analysis, and Canonical Correspondence Analysis yielded combination of factors that were useful in identifying spectrum of

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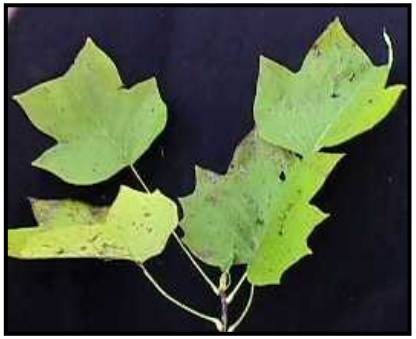
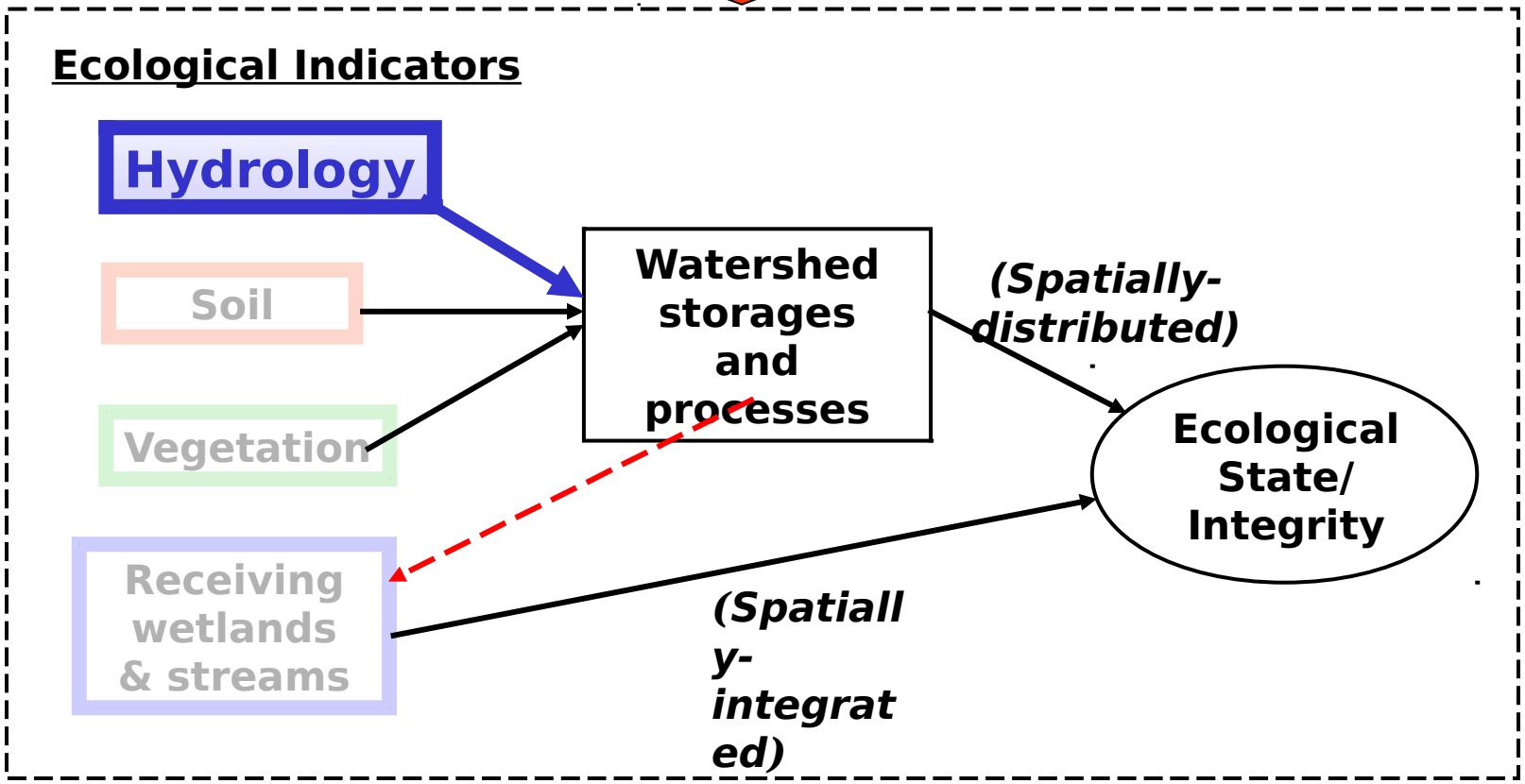
Research in Report FY 2001-02



Spatio-temporal change

- Intrinsic/natural factors
- Extrinsic/anthropogenic factors



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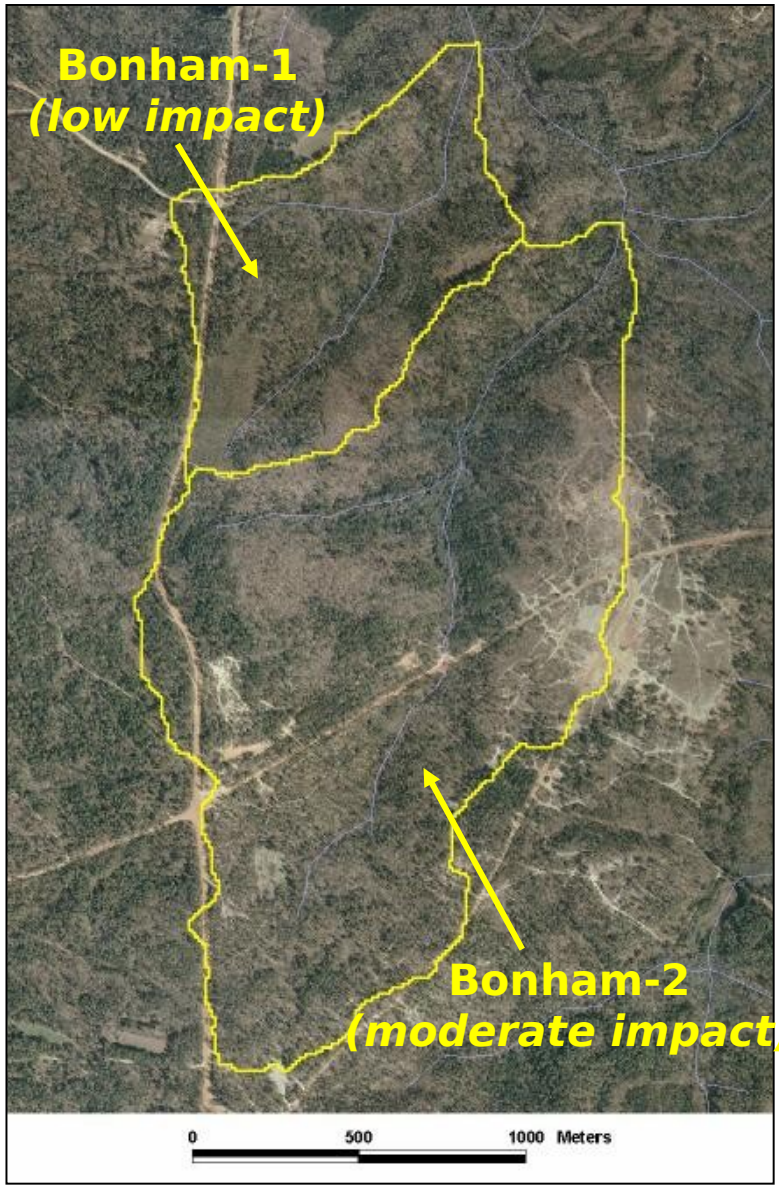

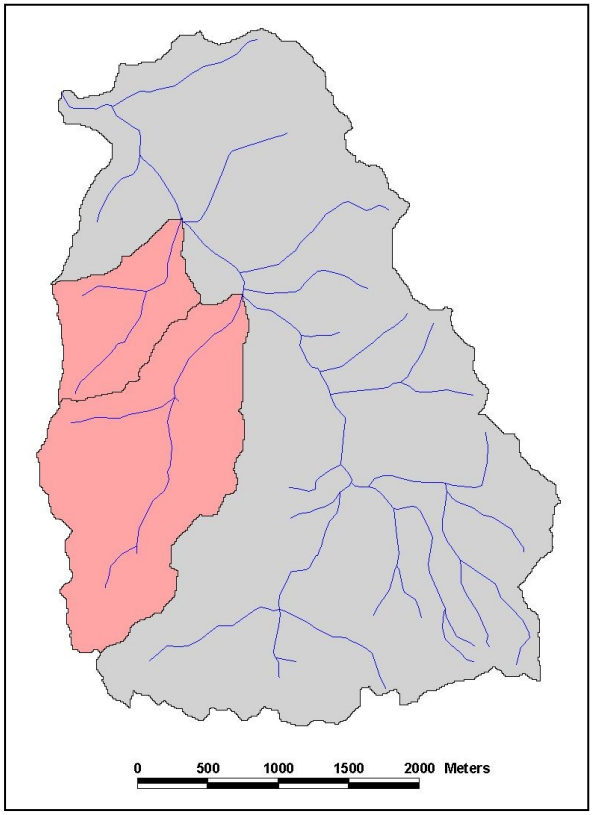

Measurement of Hydrologic Properties

2nd Order Watersheds

Bonham Creek

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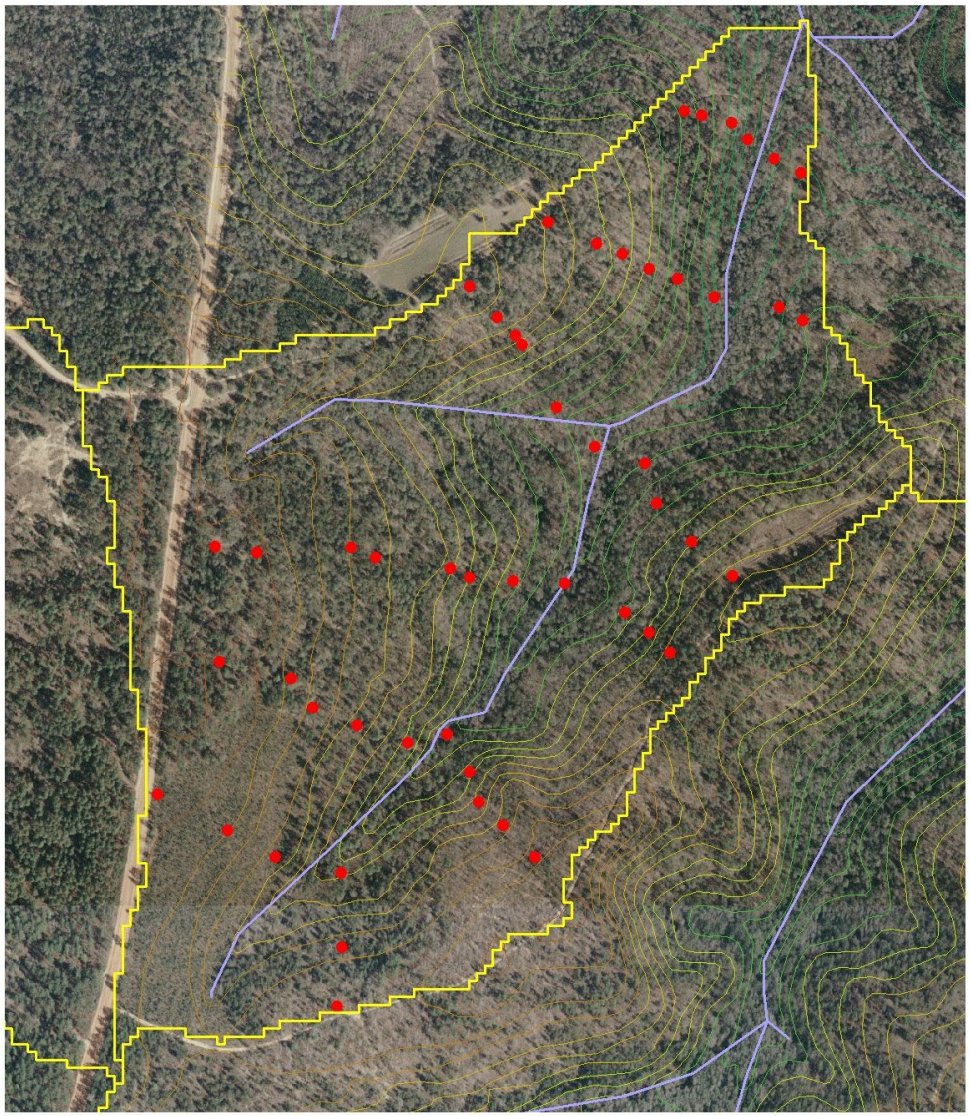
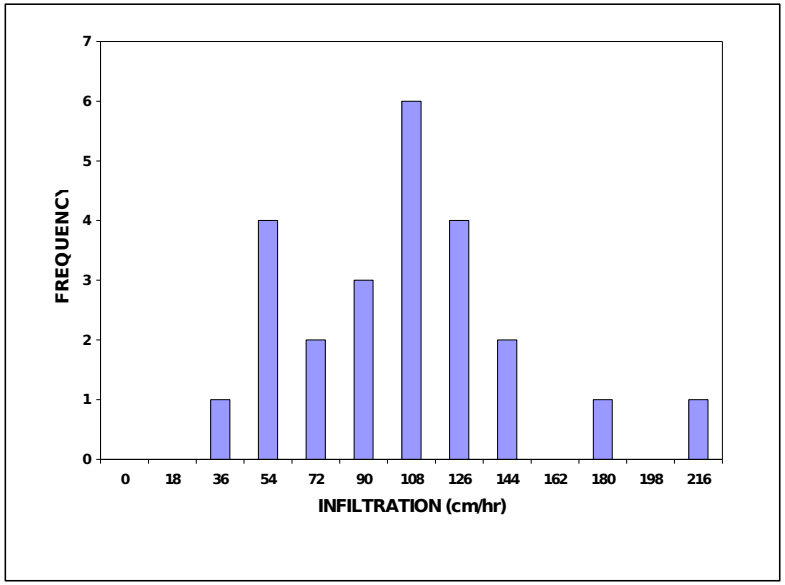
lydrologic Properties

Low-impact watershed (Bonham-1)

- Hydraulic conductivity
- Field infiltration rate
- Depth to clay





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Measurement Of Hydrologic Properties

Stream bed measurements

Water quality monitoring

Stream stage-discharge monitoring

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Measurement of Hydrologic Properties

Canopy throughfall collection

Intact soil cores

Throughfall Measurements

Goal: To develop a measure of precipitation available for infiltration and runoff

- **Bonham 1**
  - Undisturbed (baseline)
  - 26 stations (collocated with soil cores)
  - Installed 1/26/00
  - Monitored on 3 dates
  - Rainfall 0.5” to 2.0”
- **Bonham 2**
  - Moderately Disturbed
  - 26 stations
  - Installed 12/9/99
  - Monitored on 7 dates
  - Rainfall 0.5” to 2.0”

Future research tasks:

- Continued monitoring
- Characterization of vegetation at each station
- Development of throughfall model

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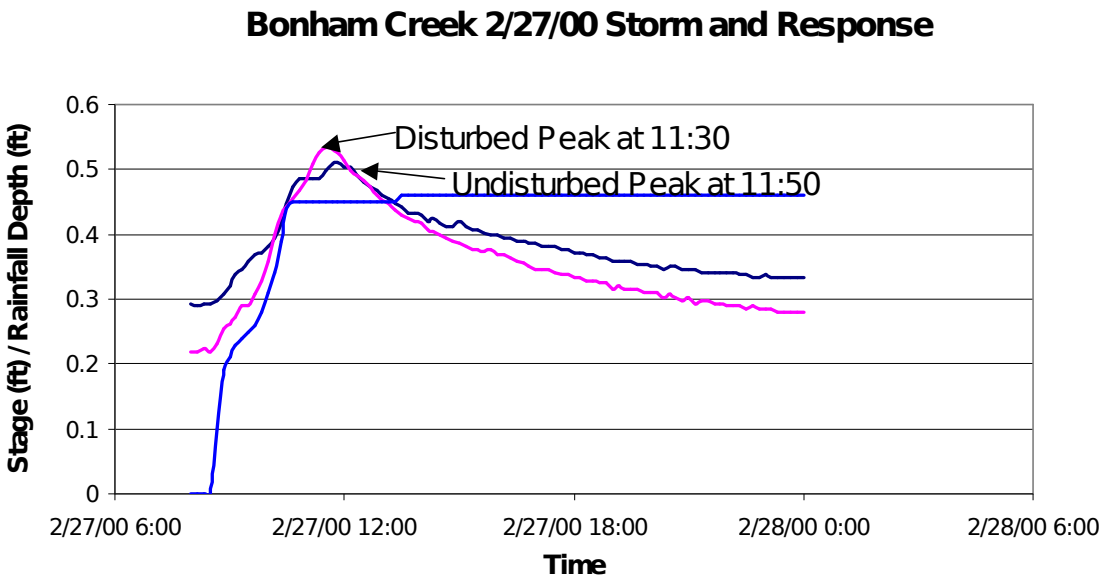
Runoff Measurements

Goal: Develop measures of stream runoff necessary for water quality and quantity characterization

2 Stage recorders in Bonham 2nd order watersheds B1 and B2

- **Installed on 11/18/99**
- **Measure stage continuously**
- **12 discharge measurements**



Spatio-temporal change

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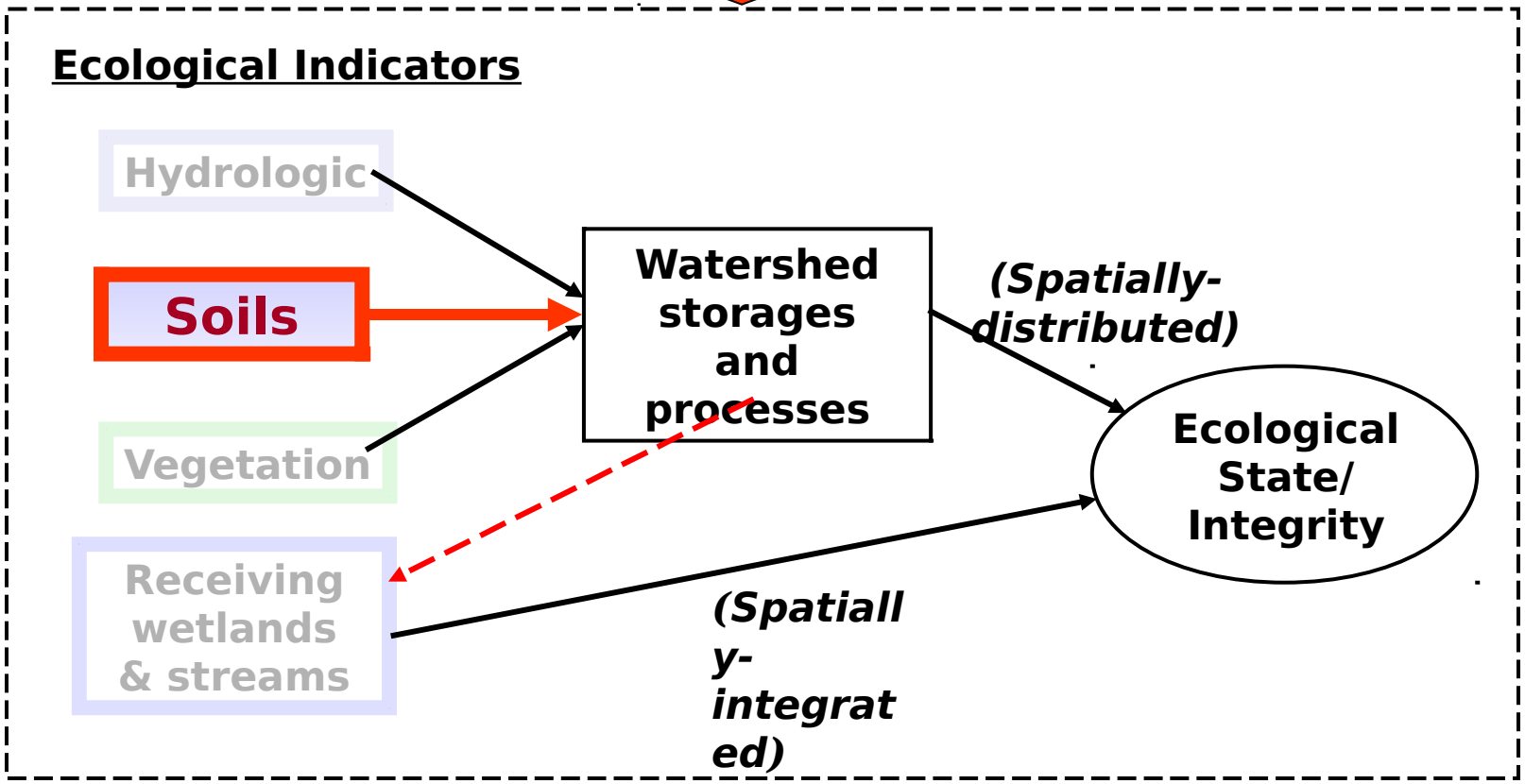

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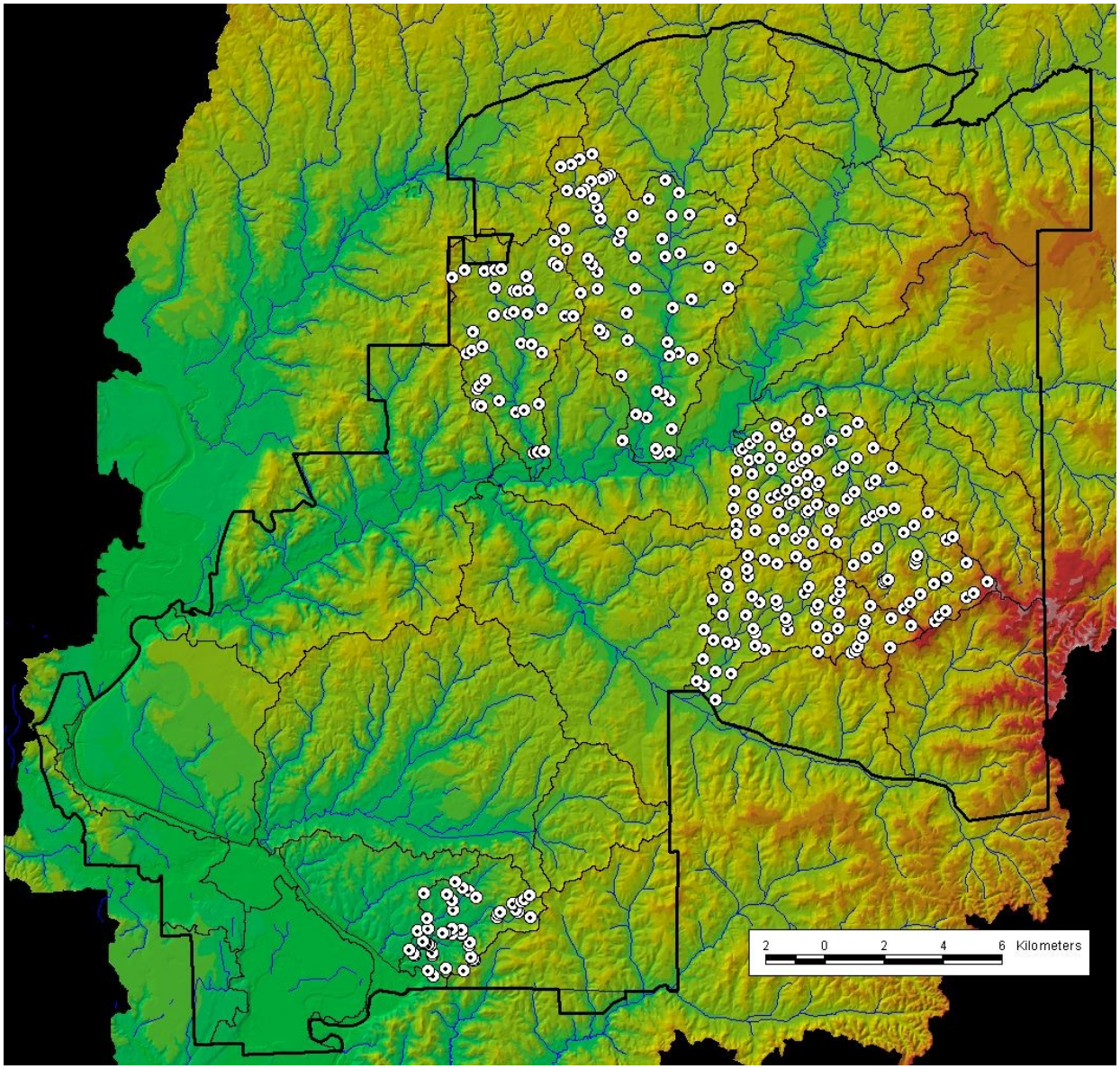


pH

Total C
Water Extractable C
Microbial C
Soil respiration (CO_2 prod.)

Total N
Exchangeable NH_4^+
Microbial N
PMN
Arginine ammonification

Total P
Water Extractable P
HCl Extractable P
Oxalate Extractable P
Mehlich-1 P
Microbial P

Mehlich-Fe, Al, Ca, Mg, K
Oxalate-Fe, Al

Acid Phosphatase
Beta-Glucosidase
Dehydrogenase
Protease
Microbial diversity

General **Criteria for Determining Level of Impact**

- **Low use-**
  - Low use military
  - Managed forest (mature forest)
- **Moderate use-**
  - Moderate use military (no tracked vehicles)
  - Managed forest (early-mid successional)
- **Heavy use**
  - Heavy training (e.g., tanks)
  - Recent clear-cuts with severe soil disturbance/erosion

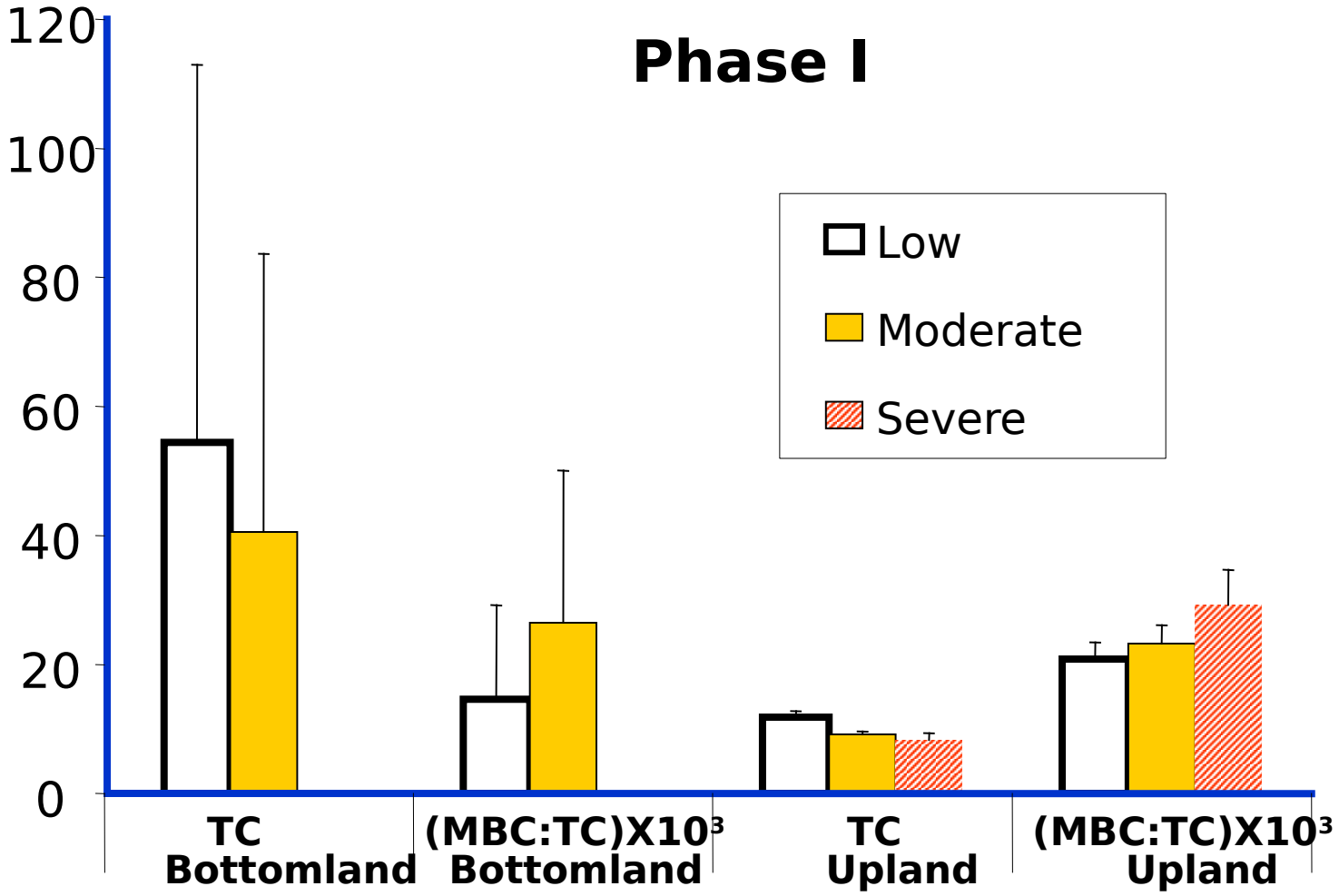
Specific Criteria for Determining Level of Impact

- **Overstory vegetation disturbance**
  - Low - None apparent
  - Moderate - Minimal disturbance
  - High - Extensive tree removal or damage
- **Understory vegetation disturbance**
  - Low - None or minimal
  - Moderate - Moderate physical impact or removal
  - High - Cleared understory
- **Ground cover disturbance**
  - Low - None or minimal
  - Moderate - Moderate physical impact or patches of bare ground
  - High - Extensive bare ground

Specific **Criteria for Determining Level of Impact**

- **Soil disturbance**
  - Low - None apparent
  - Moderate - Disturbance of O and A horizons, minimal erosion or other soil loss
  - High - Extensive soil disturbance, erosion and other soil loss, disruption of natural horizonation
- **Fire disturbance**
  - Low - Minimal (controlled burn, not recent)
  - Moderate - Recent controlled burn or more severe burn in recent past
  - High - Not used as sole criteria for severe impact

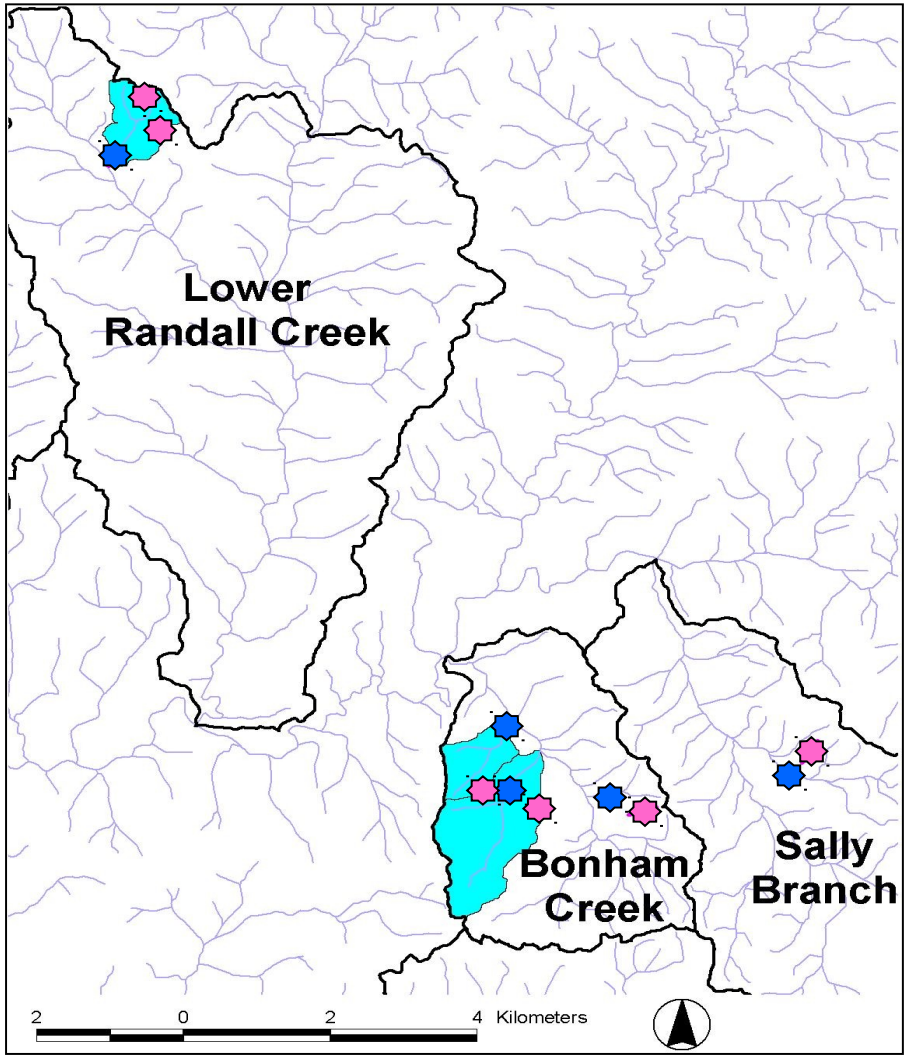
Summary of Phase I Total Carbon and MBC:TC



Phase I Summary

- Primary impacts are loss of O and A horizons in uplands
- Concomitant sedimentation in bottomlands (dilution of organic matter).
- Parameters associated with organic matter tend to decrease with increasing impact
  - Carbon (DOC, respiration, MBC)
  - TN correlates with organic matter
- TP strongly influenced by Al, Fe, organic matter

PHASE 2 Goals



- Focus on Carbon dynamics
  - MBC
  - DOC
  - Respiration
  - Enzymes
- Characterize central tendencies and spatial-temporal variability:
  - "homogeneous" sites
  - gradients of military use
  - land management gradients
- Paired Transects
- Upland area (200-400m length)
  - Troup loamy sands
- Wetlands (80-100m length)
  - Bibb soil series
- Sampled @ 20m (typical)

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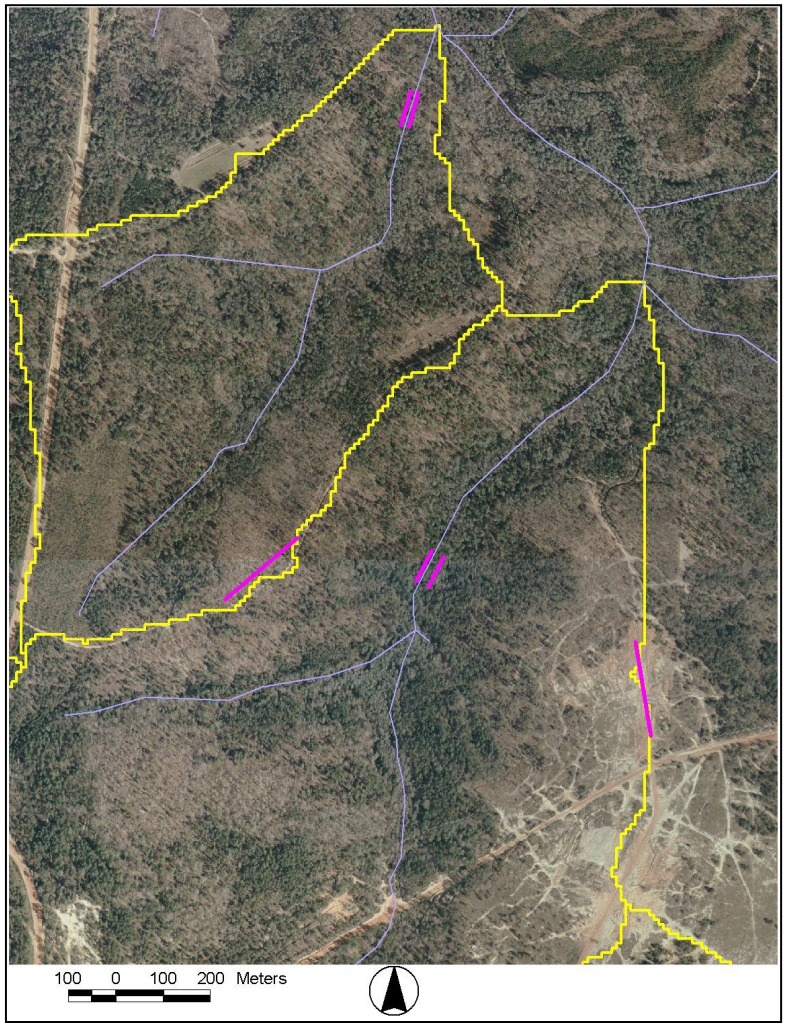
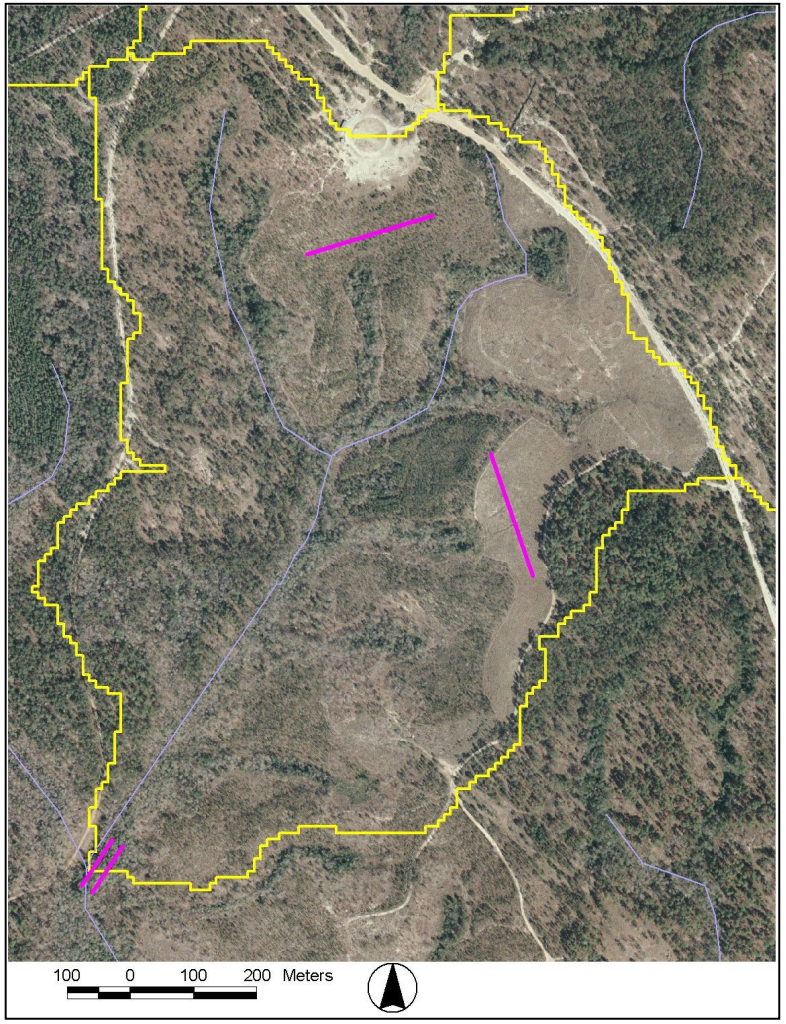
Military impacts



Forestry impacts



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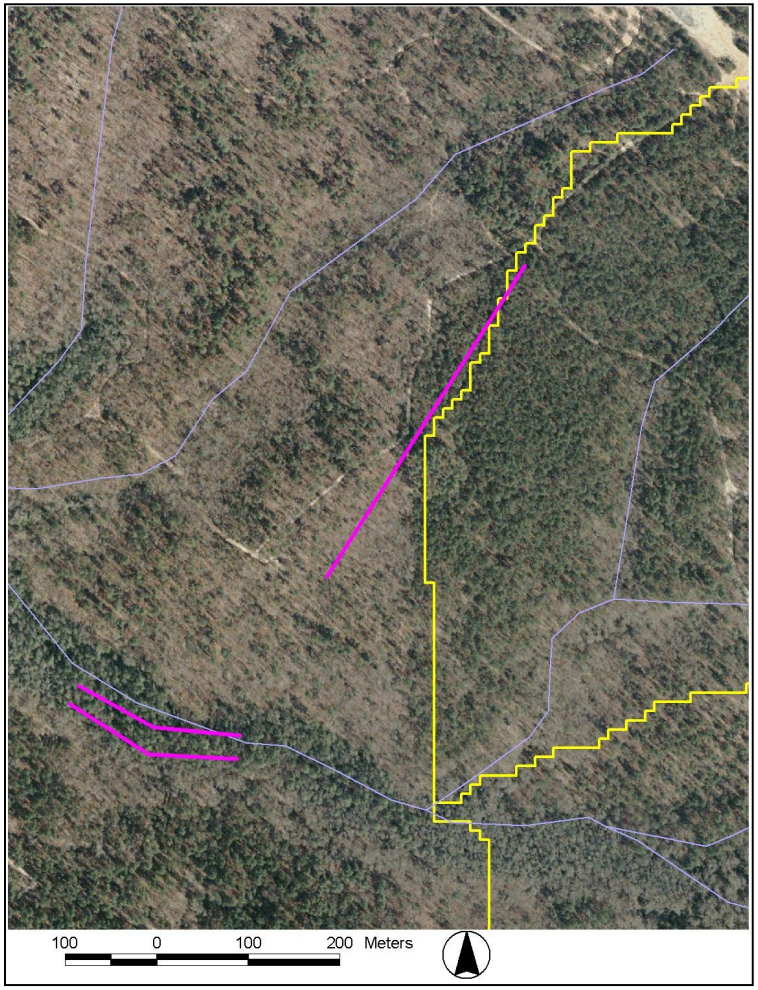
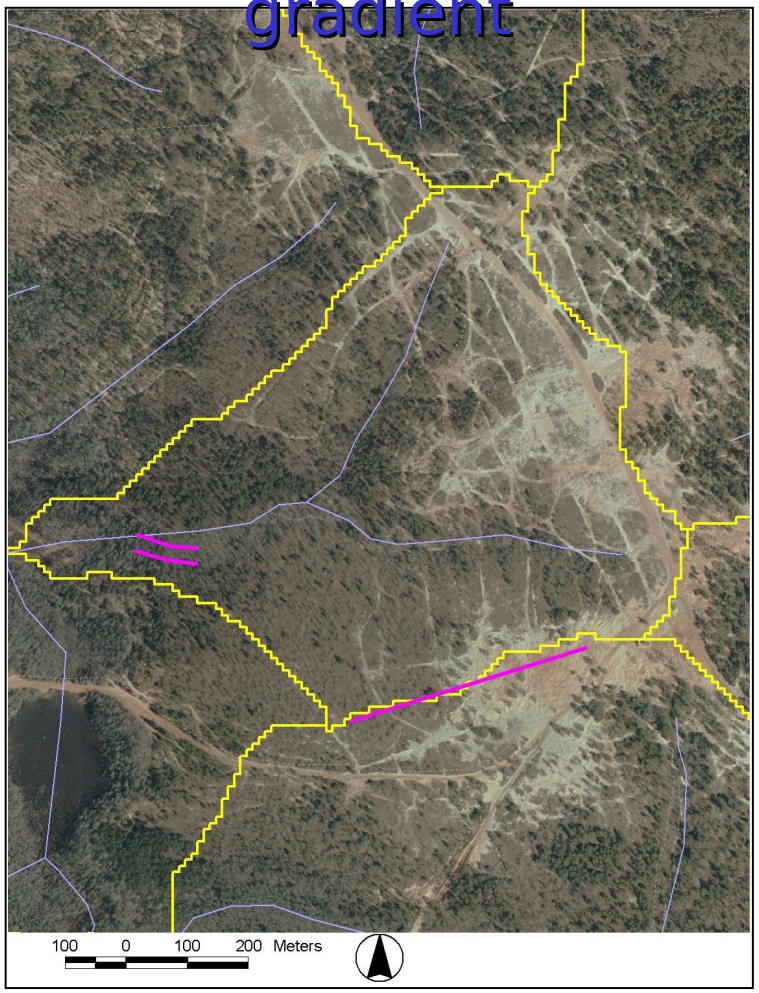
Land use gradient



Military impact gradient



DISTURBANCEAND LAND USE GRADIENTS

High-disturbance site – Military impact

Low-disturbance site – Land use/management

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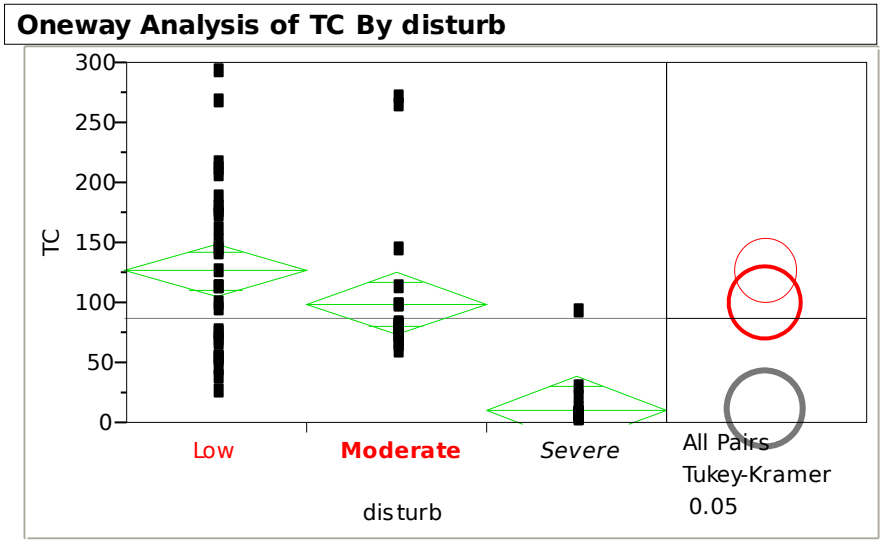
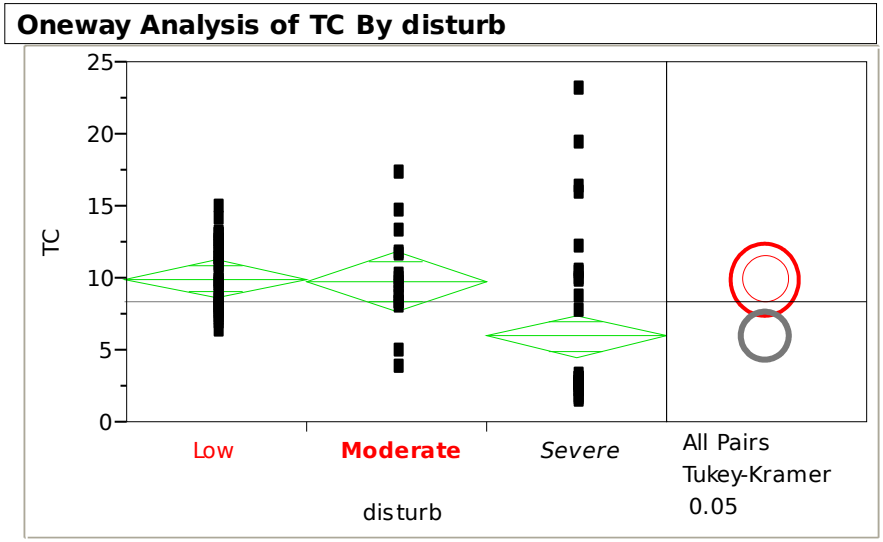
TOTAL ORGANIC CARBON

transects

Wetlands



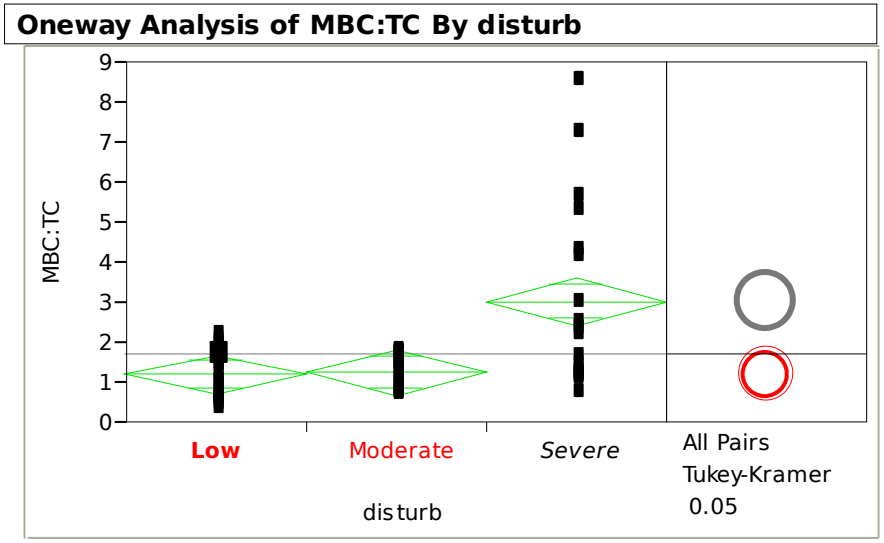
Uplands



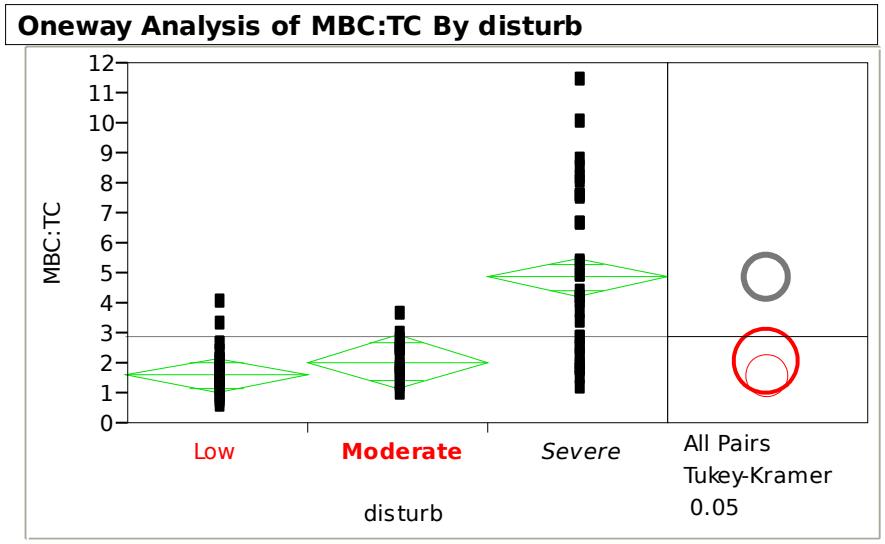
Microbial Biomass Carbon (% of TC)

transects

Wetlands



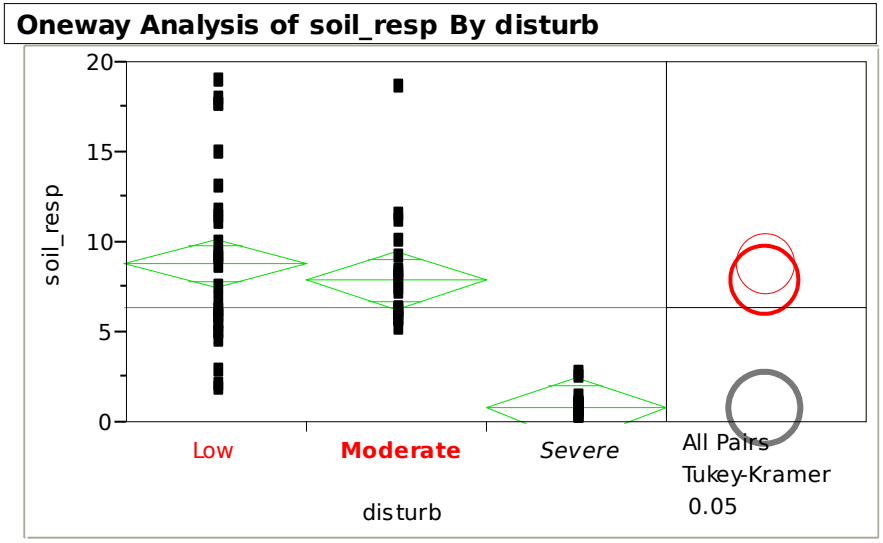
Uplands



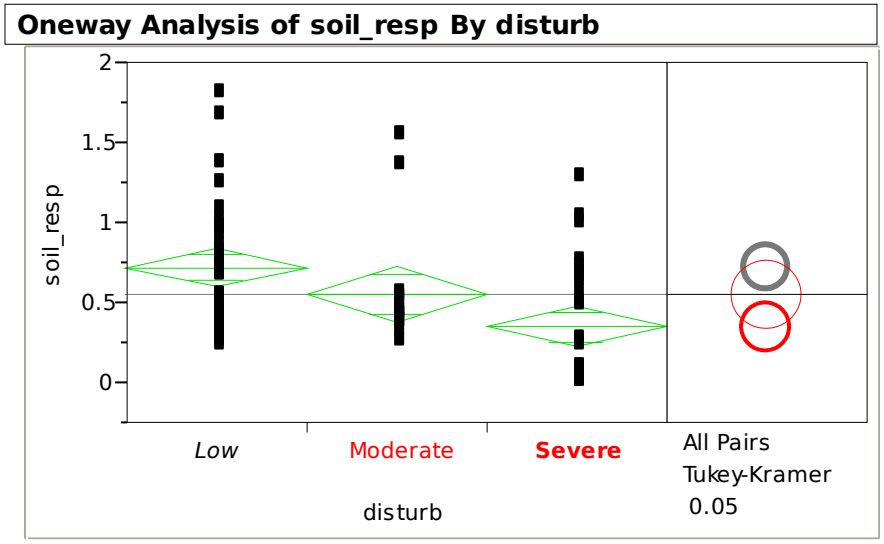
SOIL RESPIRATION

transects

Wetlands

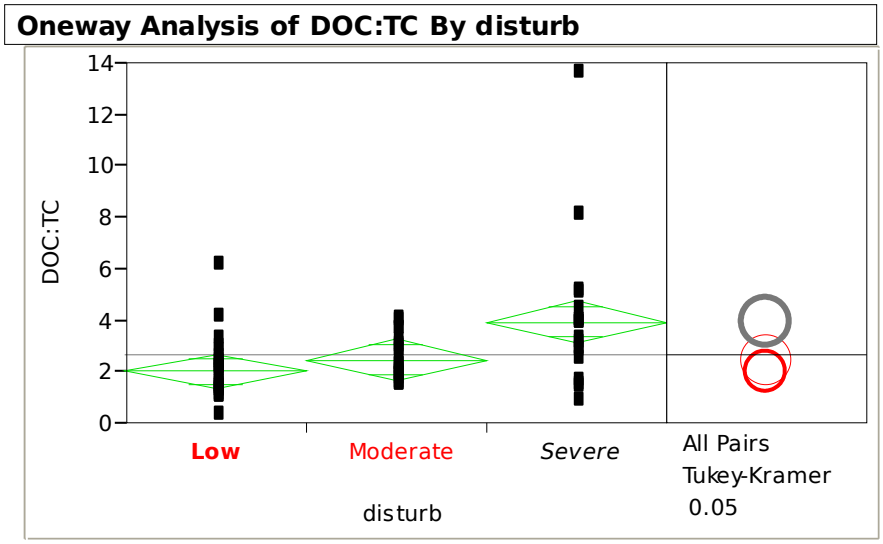


Uplands

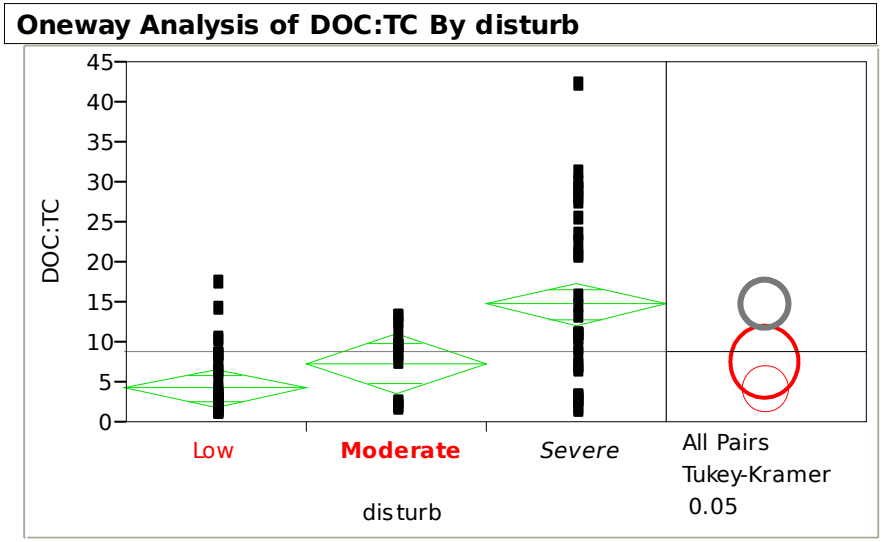


DOC (% of TC)
transects

Wetlands



Uplands



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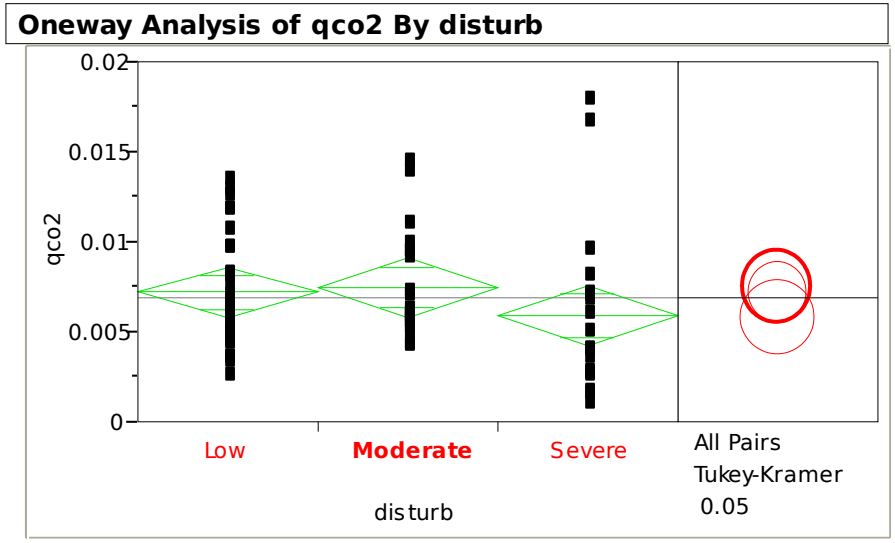
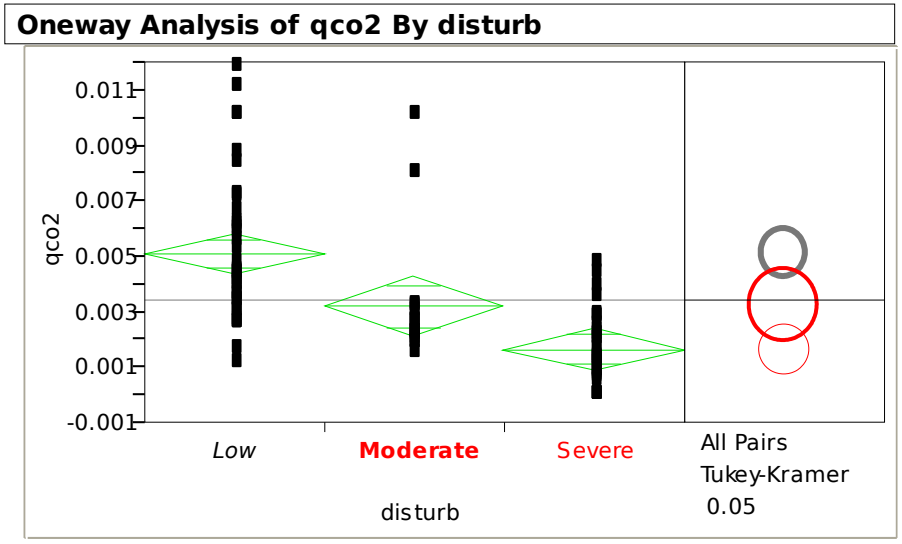
Metabolic Quotient
(respiration per unit MBC)
transects

Wetlands



Uplands



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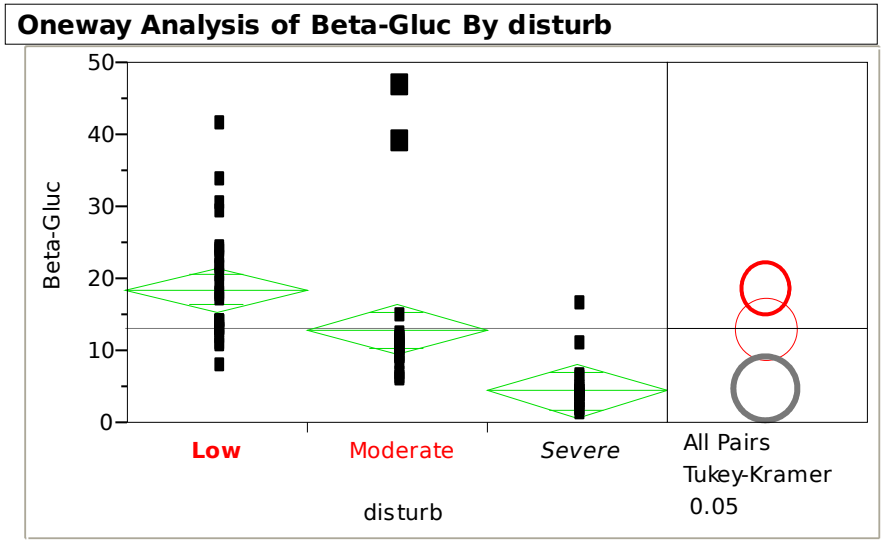
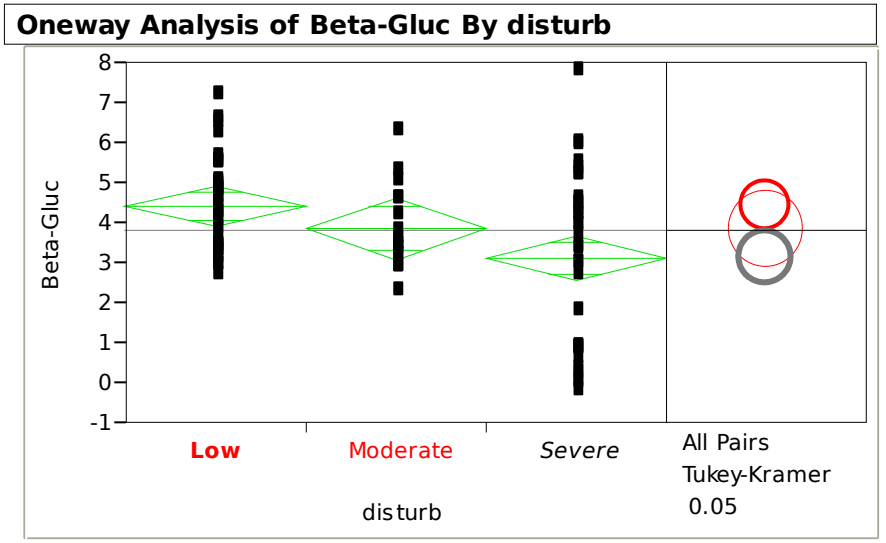
B-glucosidase
transects

Wetlands



Uplands

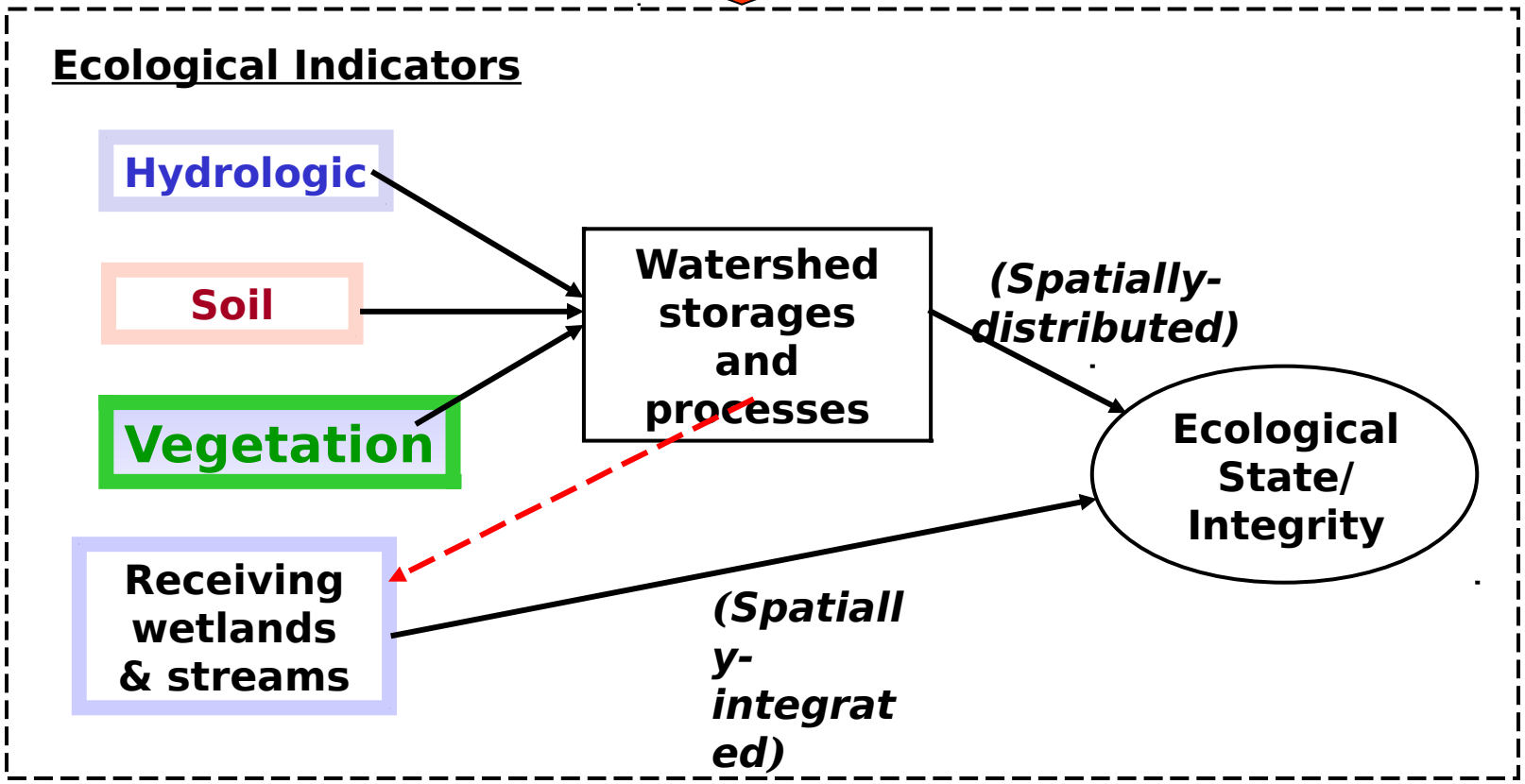


Conclusions

- Carbon dynamics dominate biogeochemistry
- Indices more useful for uplands
  - DOC:TC
  - MBC:TC
  - Metabolic quotient
- B-glucosidase distinguishes low, moderate, and high disturbance bottomlands

Spatio-temporal change

- Intrinsic/natural factors
- Extrinsic/anthropogenic factors



Vegetation Phase I Summary

- Sites corresponding to Phase I Soil sampling (>300)
- Structure and Composition Parameters
  - 113 woody species
  - 110 herbaceous species
  - Severe disturbance associated with uplands and sandy clay soils
  - CCA separates low from moderate and high
- Correlation of subset of herbaceous species with severe disturbance

Vegetation Phase II

- Focus on Chronosequence of years since clearcut
- Four time intervals
  - 0-3 years
  - 8-10 years
  - 18-20 years
  - >30 years
- Two soil types
  - Loamy
  - Sandy

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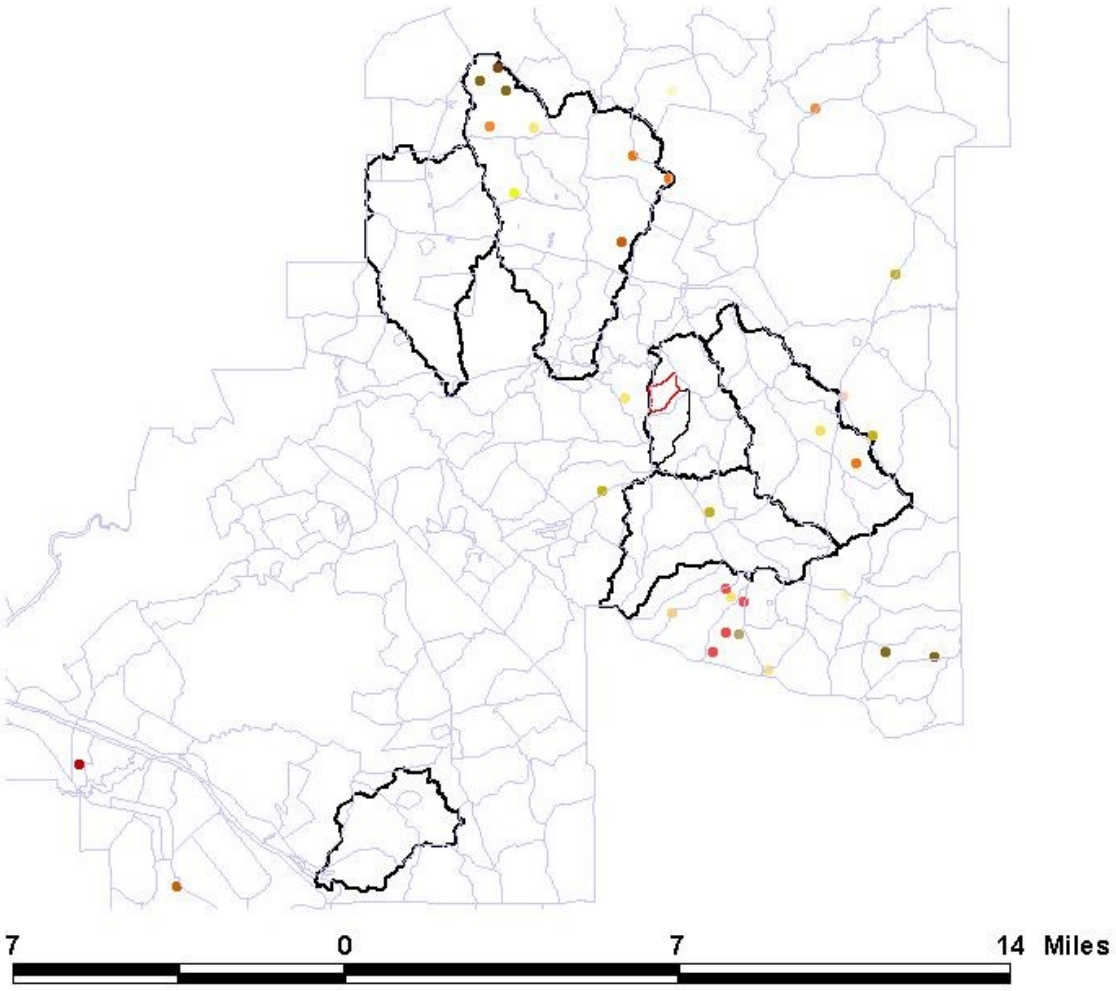
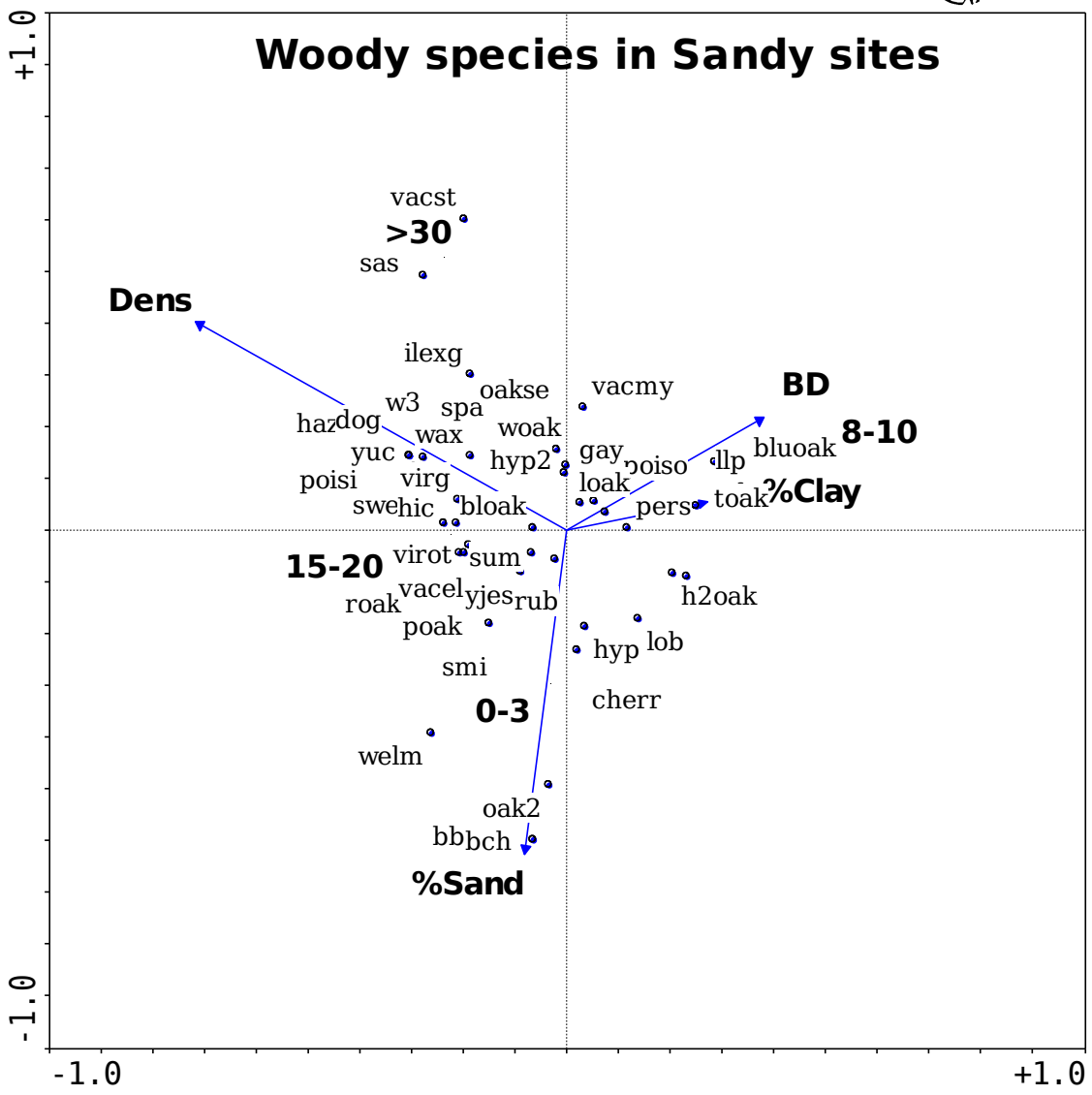
Chronosequence Vegetation Study





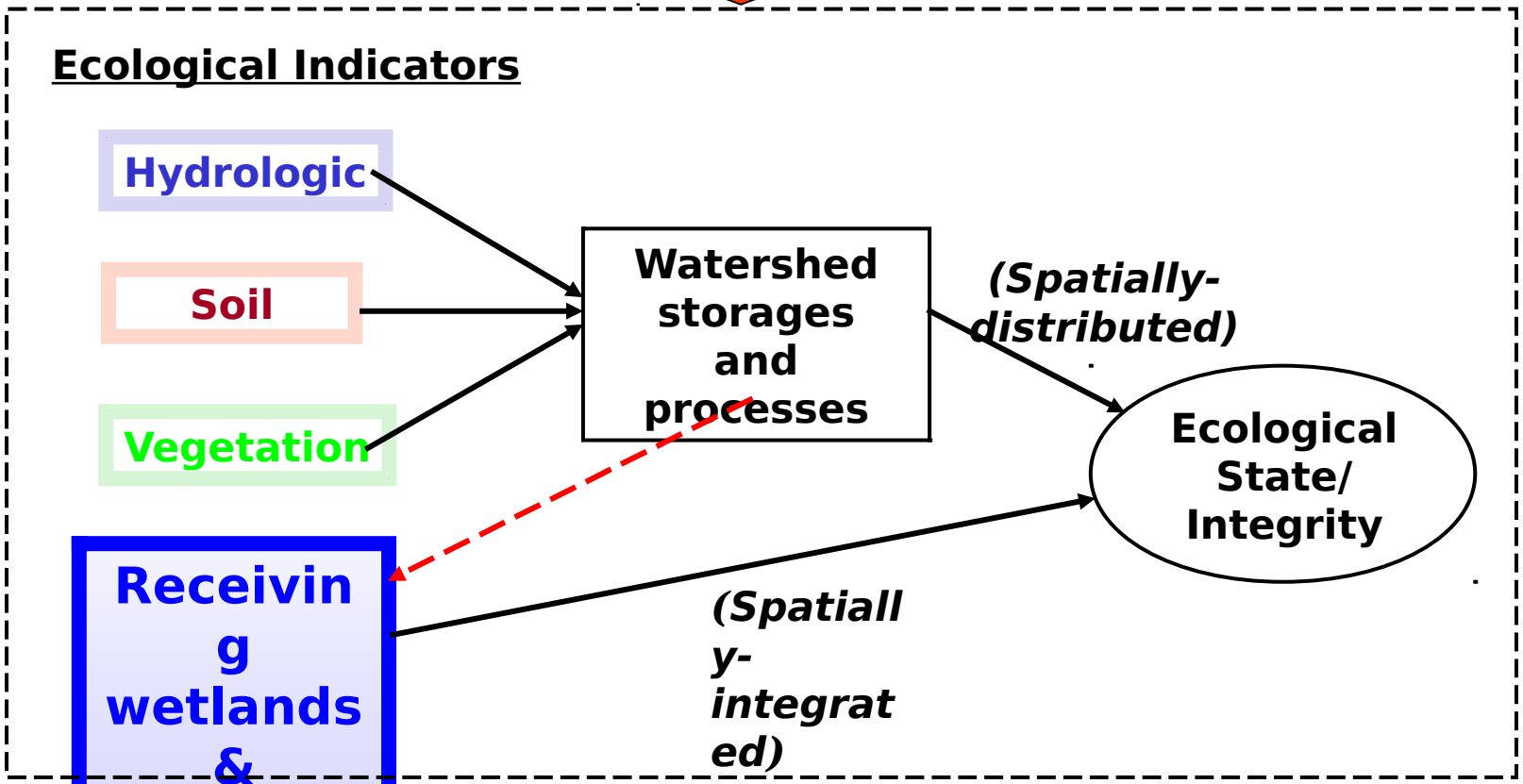
CCA biplot for woody species cover and environmental variables on sandy sites

Conclusions

- Percent clay and sand contributed significantly to variation in vegetation
- Weak separation of species based on age classes
- Increase Bulk Density associated with 0-3 yr sandy soil
- Increased overstory density associated with 15-20, >30 yr age classes

Spatio-temporal change

- Intrinsic/natural factors
- Extrinsic/anthropogenic factors



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Wetlands and Streams:

Spatial and temporal integration of watershed processe

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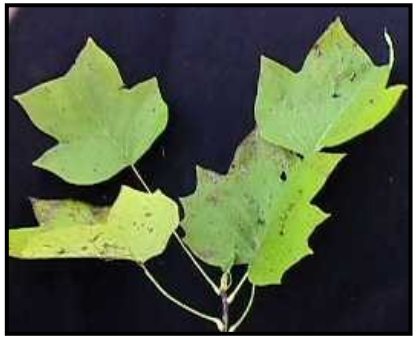
Research in Progress FY 2002-03



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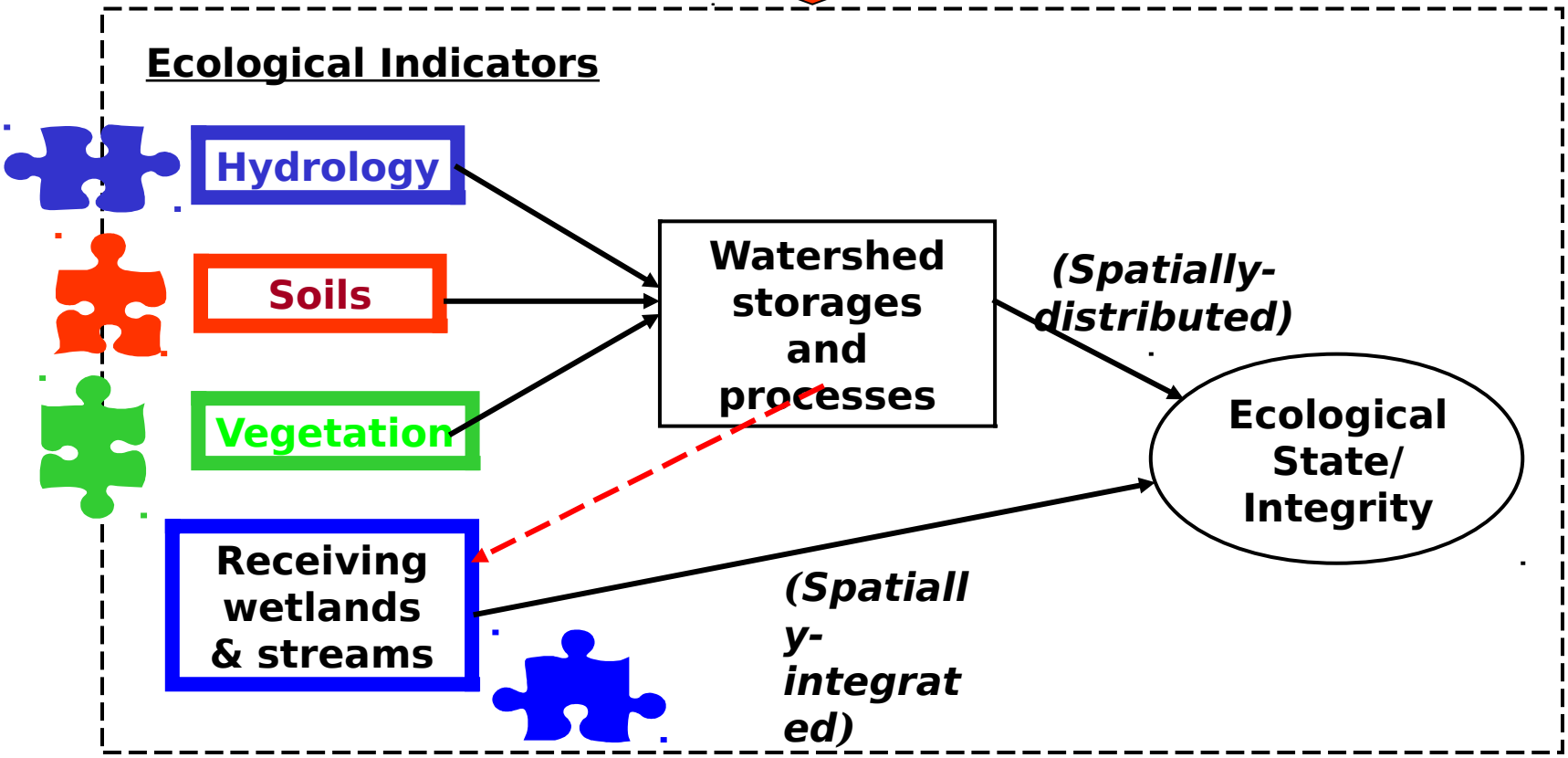
Spatio-temporal change

- Intrinsic/natural factors
- Extrinsic/anthropogenic factors



Sampling Approach

- **Phase II – Local (Sub-Basin) Scale Sampling**
  - 2nd and 3rd order watersheds within Phase I units
  - Evaluate local-scale variability and temporal trends
- **Phase III – Re-Sampling**
  - Validation of selected indicators
  - Evaluate temporal changes

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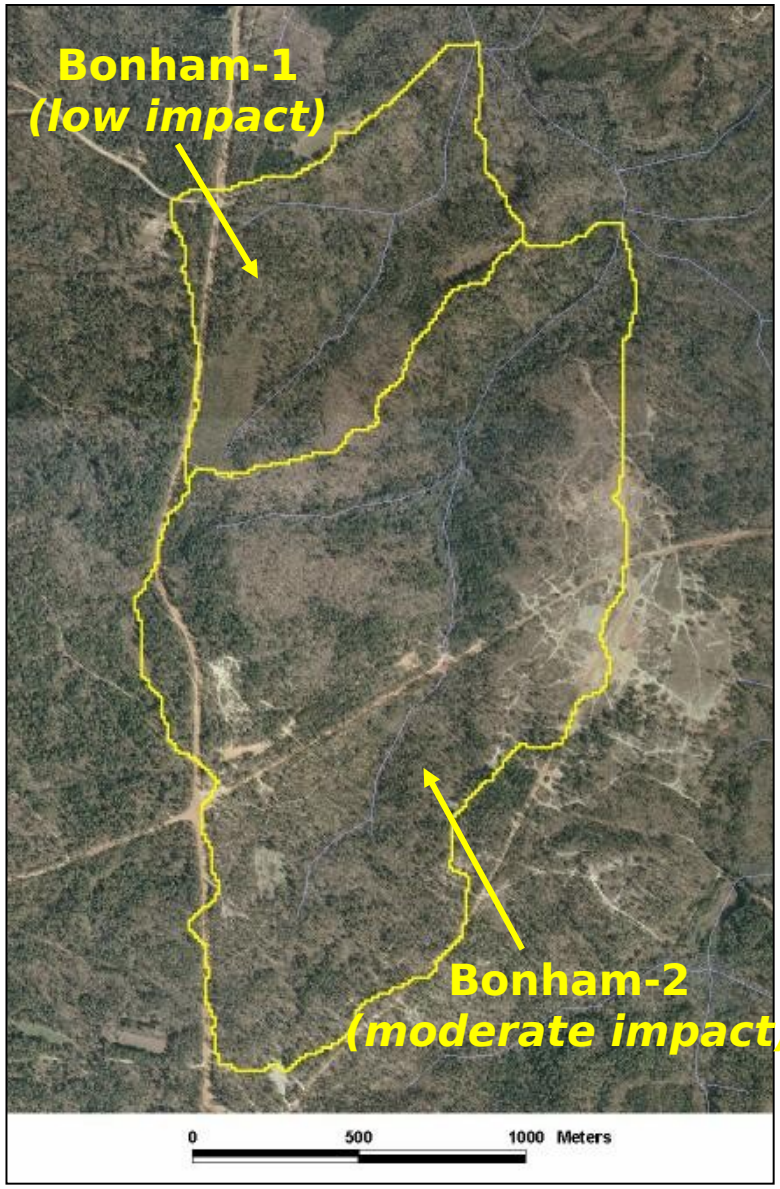

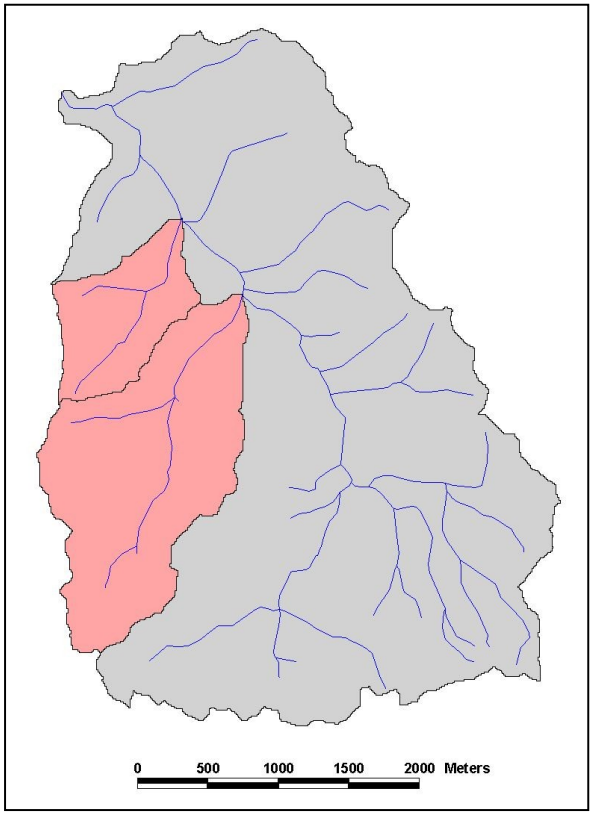

2nd Order Watersheds Bonham Creek

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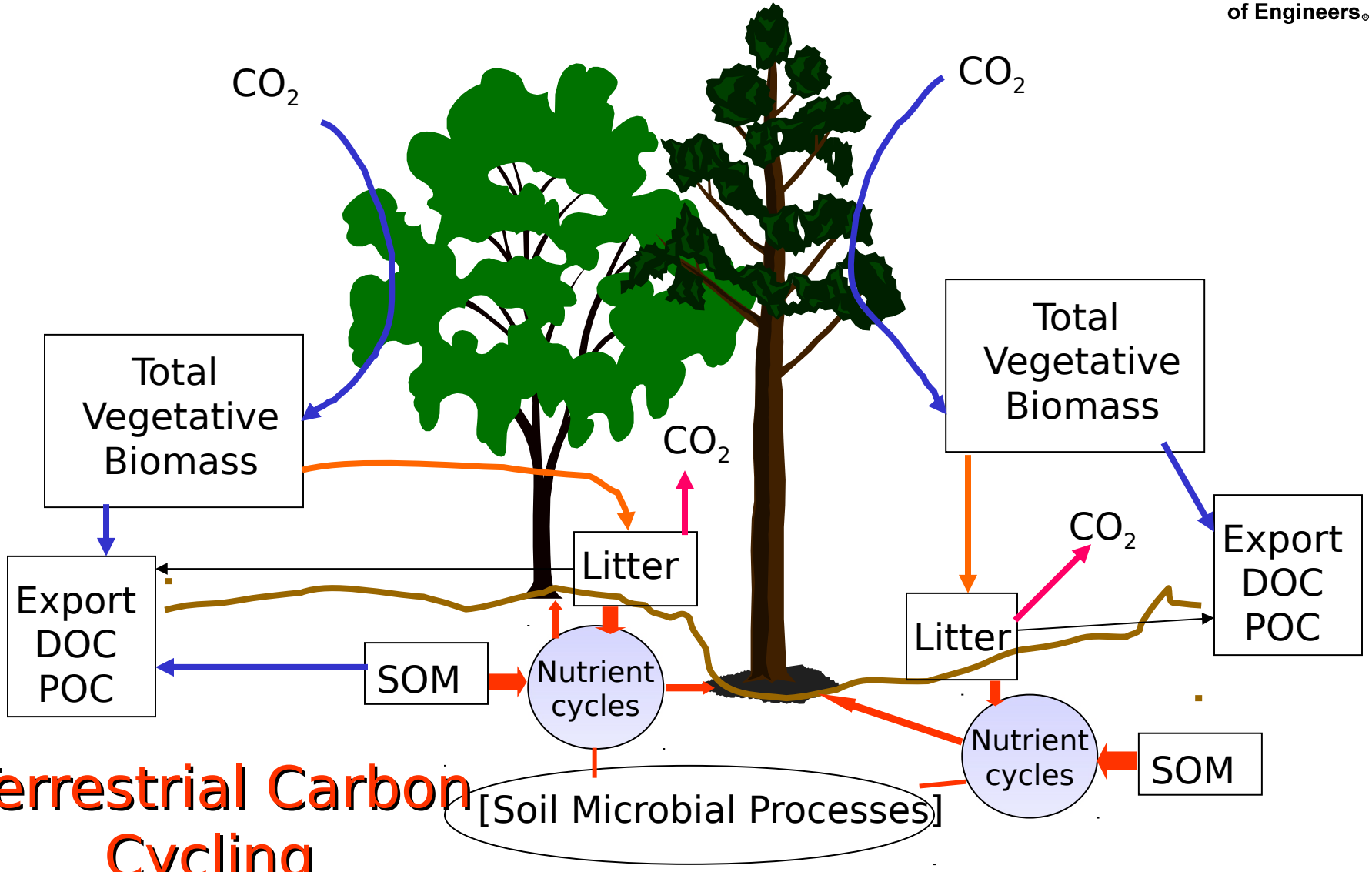

Terrestrial Carbon Cycling

Litter Decomposition: Carbon Dynamics

Objective

- Temporal responses in plant litter decomposition as influenced by land use.
  - Litter turnover rates
  - Microbial communities
  - Nutrient availability
  - Low, Moderate, High Impact
  - Bottomland and Upland

Soil Organic Matter Size and Density

Objectives

- Define the soil organic matter size and density fractions
- Determine the nutrient pools in the soil organic matter
  - Low, Moderate, High Impact
  - Bottomland and Upland

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Hyperspectral Scanning of Soils for Nutrient Status

- Determine whether spectral signatures can be used to discriminate ecological impact.
- Determine the relationship between biogeochemical properties of soils and spectral reflectance
- Conduct *in situ* analyses to determine if relationships hold in the field

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Correlation of soil biogeochemistry with watershed hydrology model

Objective

Determine soil chemical and biogeochemical parameters that affect stream and ground water chemistry

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Data Analysis and Synthesis

- **Descriptive statistics** to define frequency distribution and central tendency of ecological indicators
- **Multivariate analyses** to evaluate relationships between ecological indicators and ecological condition
- **Geostatistical analyses** to evaluate spatial patterns and spatial structure of ecological indicators
- **Predictive modeling** to forecast evolution of ecological indicators and ecological integrity

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